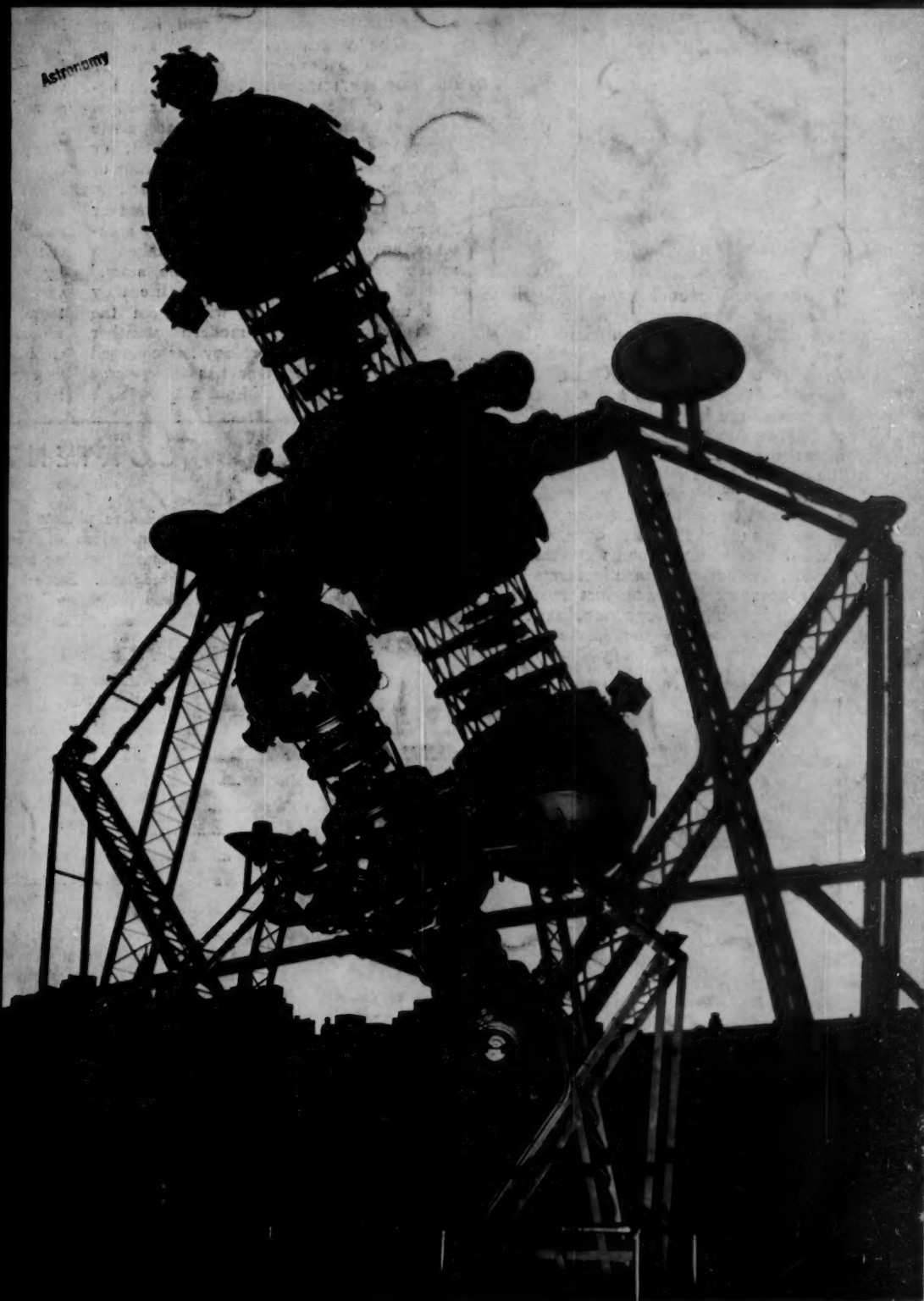




Astronomy



*Adventures of*  
**LONGINES**  
THE WORLD'S MOST HONORED WATCH



*The watch that was recalled to service\**

Thousands of men bought their first Longines strap watches while serving in World War I. The Longines military watch above was bought by an American Artillery Officer from the Quartermaster Corps in France in 1918 and received its baptism of fire in the decisive St. Mihiel and Meuse-Argonne battles. For 10 years after the war, it shared the rough and ready life on a Montana ranch; and then it was put aside. Suddenly, the years of peace ran out and war came again. Our Artillery Officer was called for active duty, and the old Longines military watch was recalled to service. Countless of such incidents have made the reputation of Longines watches—for keeping good time for a long, long time.

\*Based on documents in our files  
Longines-Wittnauer Watch Co., Inc., New York,  
Montreal, Geneva; also makers of the Wittnauer  
Watch, a companion product of unusual merit.

**Longines**

WINNER OF 10 WORLD'S FAIR GRAND PRIZES  
AND 28 GOLD MEDAL AWARDS



The beating heart of every Longines Watch is the Longines "Observatory Movement," world honored for greater accuracy and long life. \*Rev. U. S. Pat. Off.

# Sky and TELESCOPE

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## The Editors Note .

AS THIS issue goes to press, we hear the first regular weather forecast to be broadcast by radio since the war forced curtailment of this important service to the American public. The benefit to agriculture, commerce, and industry cannot be overestimated, but this event seems also to have great significance for the amateur scientist. It marks the beginning of the return to the time when we shall have more opportunity to pursue our peacetime hobbies, one of which, for many persons, has been the following of the daily weather maps and forecasts.

This is particularly true of amateur astronomers. Many of the younger amateurs, now in the Services, have taken to meteorology as "nearest to the stars," and when they return to civil life they will undoubtedly bring with them the fresh viewpoint of modern weather science. Surely, meteorology has changed as much in 20 years as has astronomy; to study the former without a knowledge

of the principles of air-mass analysis is as old-fashioned as to seek to comprehend modern astronomical observations without having learned the fundamentals of spectral analysis.

The most interesting connecting link between meteorology and astronomy from the point of view of the modern scientist is not, however, that a cloud can hide a star or dim the sun, but that conditions in the upper portions of the atmosphere, where meteorology is continually finding answers to age-old riddles, are initially induced by radiation and electrical energy from the sun. Astronomical observations of aurorae, meteors, and the light of the night sky are of great value, but another science, electronics, is the key to the study of this relationship, and some say that electronics has been advanced more by the war than any other field of investigation. Therefore, the amateur astronomer who looks forward to keeping up with the astronomy of the future may well seek out these related subjects, meteorology, electronics, and the like, and learn all he can about them.

VOL. III, No. 1  
Whole Number 25

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NOVEMBER, 1943

**FRONT COVER:** The Zeiss projection planetarium as it appears today, 10 years after its installation in the Fels Planetarium of The Franklin Institute, Philadelphia, Pa. The shadow is produced by special lighting and shows some details of the instrument not visible directly in this photograph. Some buildings of Philadelphia are represented by the horizon silhouette. The projection instruments of four other American planetariums are identical with this one. Fels Planetarium photograph.

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**BACK COVER:** The great bolide of August 13, 1928, photographed by M. de Kerolyr at the Astrophysical Station at Haute-Provence, France. The region is that of Cygnus, with Deneb near the right-center edge of the picture and the North America nebula between it and the meteor. Note the variations in brightness of the meteor, as well as corresponding changes in the amount of halation, which produced the wide "ghost" on each side of the fireball's image. This engraving was made from an original print in the possession of Dr. Charles P. Olivier. (See page 9.)

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## PART I

ON NOVEMBER 6, 1933, after several days of previews for special groups, there were given the first public demonstrations in the Fels Planetarium of The Franklin Institute in Philadelphia. Already, in Chicago, more than two million visitors had thrilled to the demonstrations of the first such installation in the Western Hemisphere, and in Europe, where the instrument had originated almost a decade earlier, many other millions had sat in such "theaters of the stars."

But the full story of the planetarium begins much earlier, when men first tried to understand the behaviors of the bodies of the universe, and dreamed of duplicating their motions with mechanical models.

There is a legend to the effect that Archimedes possessed a machine to reproduce the motions of the planets, but the first such device whose quality we can be sure of is the fine mechanical planetarium constructed by the eminent clockmaker, Johannes van Ceulen de la Haye, in 1682, after a design by Christian Huygens.

In this machine, still preserved at Leyden, the motions of the planets are shown with their proper relative speeds. The problem of designing the gear trains for such a device is one which is met in the modern planetarium, so we might spend a little time here thinking of it.

As an example, the planet Mars requires 1.88082 . . . years to revolve around the sun (the dots following the number indicate that there are more numbers that could be written down, but that the ones which have been written down are enough). The problem is to devise gears with numbers of teeth which will, when properly matched in train, give a ratio between the motion of Mars and that of the earth very

nearly equal to the true ratio as given above. After a little trial, we find that there are three fractions which may prove useful:

$$\frac{43}{50} \times \frac{54}{20} \times \frac{81}{100} = 1.88082.$$

These numbers—43, 50, 54, 20, 81, 100—can be used for the numbers of teeth in the six gears which will reproduce the motion of Mars relative to that of the earth with an accuracy of one part in almost 200,000. Another way to put it is to say that in a model using these gears, Mars could make more than 500 trips around the sun before its position would be in error by a single degree.

But suppose we want to use fewer

gears. We might, after a few trials, hit upon these fractions:

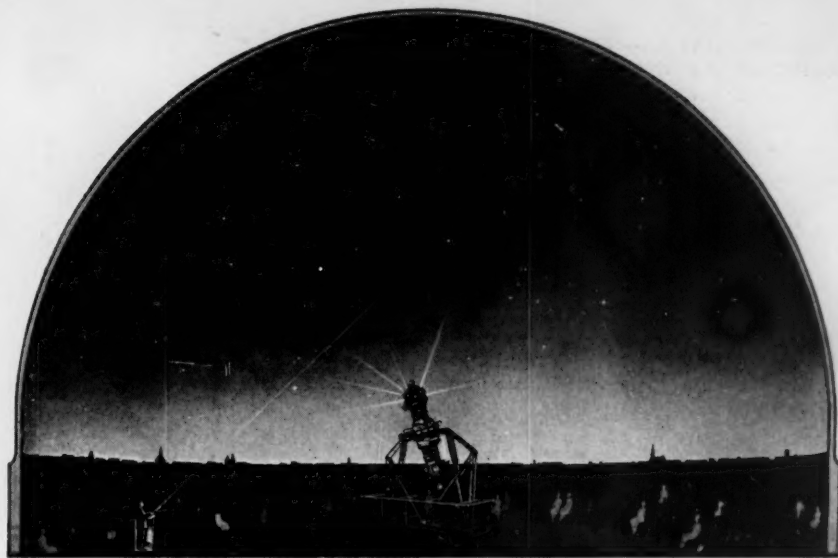
$$\frac{33}{20} \times \frac{57}{50} = 1.881.$$

Four gears, with teeth numbers equal to 33, 20, 57, and 50, will give very nearly the correct value of the ratio we are trying to reproduce; the error is less than a hundredth of one per cent.

We decide what degree of accuracy we wish to have, then we have the gears cut. For such an instrument there is little hope of finding gears with such odd values as 57, 43, or 81 teeth already available; they must be cut especially for the job. As a result, few very accurate models of the planetary motions have been made; the time and expense involved are too great.

Some time shortly after 1700, George Graham made such a model for Prince Eugene; this was copied and somewhat improved upon by John Rowley in an instrument for Charles Boyle, fourth Earl of Orrery. The instrument was dubbed an "orrery" by Sir Richard Steele, editor and essayist, and today such devices are commonly known by that name.

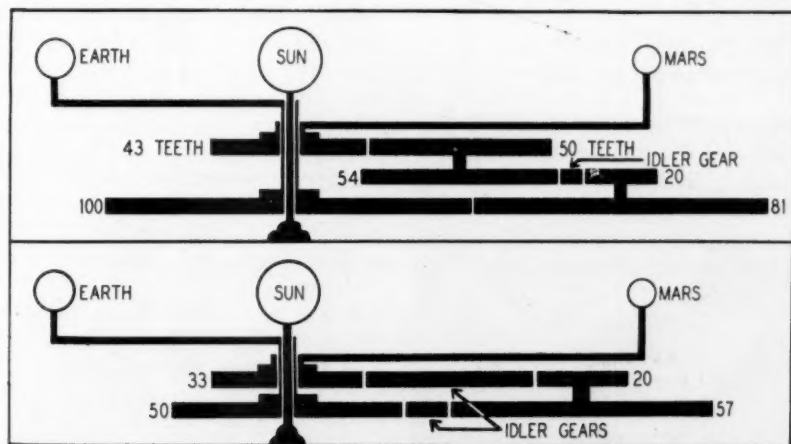
Very fine orreries were made by Eise Eisinga at Franeker, Holland, about 1775, and by P. M. Hahn and A. de Mylius about 1790. Several were made (beginning in 1767) by David Rittenhouse, of Philadelphia, one of the best being still preserved at the University of Pennsylvania. Many others were made and incorporated in great cathedral clocks (as at Strasbourg). But all these devices show the solar system as seen from outside.



# THE PLANETARIUM

BY ROY K. MARSHALL

*Fels Planetarium, Franklin Institute*



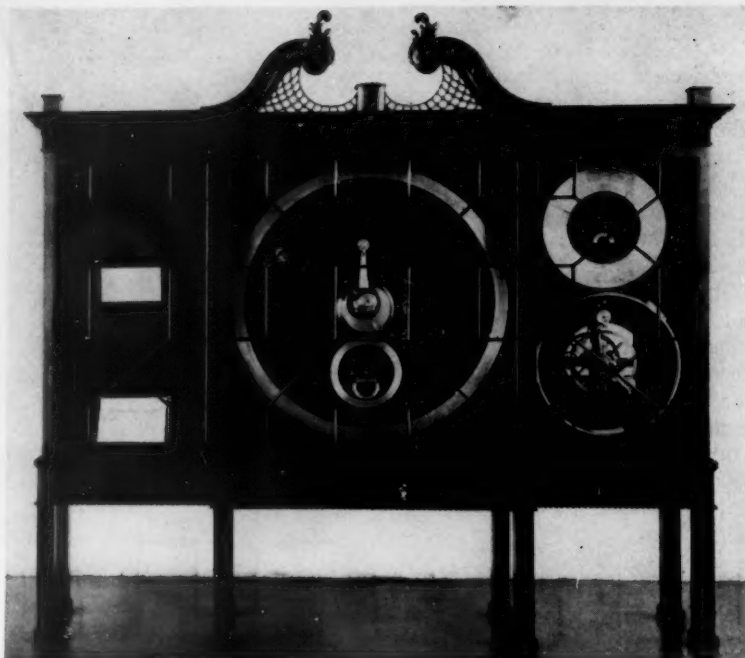
A sample of orrery construction illustrates the use of fractions derived in the text for expressing the ratio between the periods of Mars and the earth. Both examples are illustrated here. Gears indicated as "idlers" are unimportant in attaining the correct relative motion; they are inserted in the mechanism either to get both planets turning the same way or to bridge the gap between two gears which would otherwise not meet; they may have any number of teeth and may be mounted in any way.

In the Deutsches Museum in Munich, about 1920, there was put into operation an orrery in which the outermost orbit shown, that of Saturn, has a diameter of approximately 30 feet. At the earth, which revolves around the sun once in 12 minutes, a moving platform carries an observer along; from this station he can look at the other planets and note their relative positions either through a strongly minifying periscope-like device or with the unaided eye. In New York, in the ceiling of the circular room beneath the Hayden Planetarium chamber, a large orrery operates. The observer may stand beneath any of the planets and see the relative positions of the others. The planets in this orrery operate independently, however, so that without careful setting only typical configurations and not necessarily true ones of a certain date are represented.

During the last century and the early part of this one, these devices to represent the motions of the planets were very popular, particularly for classroom instruction. Stored away in attics are many examples of such devices, most of them not even pretending to represent either relative distances of the planets from the sun or relative speeds in their orbital motions. But the fine ones mentioned above brought the art of design and construction to a high peak.

**N**OT SO often have the stars been represented, however, in a form other than that of the conventional celestial globe. It is interesting that the concept of a spherical universe, or celestial sphere, was accepted in very ancient times, and never seriously questioned until comparatively recent times. Indeed, the very appearance of sphericity of the heavens was used as an argument against the motion of the earth; for, if the universe was spherical in form, there must

**The Copernican planetarium at New York's Hayden Planetarium is a modern orrery which shows the planets out as far as Saturn.**



**The Rittenhouse orrery, now at the University of Pennsylvania, shows, in the center, the relative motions of the planets, through Saturn, with great accuracy. The right-hand section shows the movements of the moon, and is essentially an eclipse computer; it displays the year, month, and day of eclipses for 5,000 years before and after 1769, the year of its construction. The left-hand section was intended for detailed models of the systems of Jupiter and Saturn, but these were never built.**

be a center, and since the earth appeared to be the center so it must be and remain, hence it could not move.

Tradition has it that a fine celestial globe was made, or at least possessed, by Eudoxus of Cnidus (c. 350 B.C.). A very fine globe from about the same period is the Farnese Atlas, which is the earliest complete representation of the sky that has been preserved. The pictures of the constellation figures are carved on this globe in exquisite detail.

Celestial globes give a reversed representation of the sky; the observer is in a most artificial position outside the uni-

verse, looking in. But Erhard Weigel, of Jena, made in 1699 a celestial globe of thin metal in which the stars are perforations. Several holes large enough to permit a view inside the sphere have been cut in relatively starless regions of the globe. When the observer looks through one of these larger holes at the opposite side of the globe, the light outside which comes through the star-perforations makes them show up very nicely. This globe is now one of the most important exhibits in the astronomical section of The Franklin Institute, and is displayed with an incandescent lamp in the center, so the star-perforations can be seen with no difficulty; again, however, this procedure shows the sky as seen from the outside.

The proper way to represent the heavens is to make a celestial globe so large that the observer can get inside it. This was what was done about 1655 at the instance of Duke Frederick of Holstein-Gottorp; the actual construction was by Andreas Busch, of Limberg, under the direction of Adam Olearius. The sphere was about 11 feet in diameter; in its center was a platform which could accommodate 12 people. The stars were painted on the inside of the globe, and illuminated by a lamp near the center. The globe itself was rotated by water power, to simulate the daily apparent revolution of the celestial sphere; the platform, of course, was supported in such a way as to remain fixed. As late as 1901, this interesting

machine was still in existence in St. Petersburg, Russia.

About 1670, Erhard Weigel made a similar globe 10 feet in diameter; inside it there were many accessories, with the assistance of which it was possible to reproduce the phenomena of meteors, rain, hail, lightning, thunder and volcanoes!

The most famous of these large globes is the one constructed about 1758 by Roger Long, the first Lowndes' Professor of Astronomy and Geometry at Cambridge. It was about 18 feet in diameter, and was turned by hand, from outside. About 30 people could be accommodated on the platform inside it. The stars were pierced through the metal of which the sphere was made; so the light from outside passed through the perforations, and showed the star images in very realistic fashion.

This "Uranium," as Professor Long called it, fell into disuse, and it was removed from Pembroke Hall and destroyed in 1874. It is somewhat surprising that the Science Museum at South Kensington, London, to whom it was offered as a gift, should have refused it, and thus doomed it to the junk pile.

A similar device built in this country has fared somewhat better, although it is true that it is hardly a third of a century old. At the Chicago Academy of Sciences, in 1911, there was conceived what has become known as the Atwood Celestial Sphere. Dr. Wallace W. Atwood, president of Clark University, but then director of the Chicago Academy, designed the instrument; it was constructed, installed and presented to the Academy by LaVerne W. Noyes, then president of the Board of Trustees of the Academy, in 1913.

There are a few innovations in the Atwood Sphere, which is 15 feet in diameter. For example, it is driven by electric motor, controlled from the platform inside. As in Long's Uranium, the stars are perforations in the sphere, but the sun is shown by an electric light which may be moved along from day to day to its new position among the stars. The moon is shown by several disks cut out to correspond to the various phases, and coated with luminous material.

**THE MENTAL** transition from this type of instrument to the "optical" or "projection" planetarium is an easy one. Indeed, it was something like the Atwood Sphere which was in the mind of Professor Max Wolf, of Heidelberg, when he spoke of an astronomical exhibit to Dr. Oskar von Miller, of the Deutsches Museum in Munich. And Dr. von Miller suggested to the Zeiss Works that they "place the observer upon a platform on the Earth, regarded as motionless according to the ideas of

At the Society of Artists in 1766, this picture bore the description, "A philosopher giving that lecture on the orrery in which a lamp is put in place of the sun." The painting, by Joseph Wright, is now in the Derby (England) Corporation Art Gallery; the original print of the William Pether engraving, from which this cut was made, is in the Adler Planetarium, Chicago.



ancient astronomers, this platform to be built up within a great rotary metal dome, the celestial sphere. The planets of the ancients, attached to different mechanisms, were to be moved upon the inside surface of the sphere in accordance with their actual apparent motions." . . . "Much experimental work was carried out on the lines of von Miller's suggestions but no satisfactory solution . . . to create the illusion of the mysterious, silent march of the worlds of Nature . . . was found."

The concept of optical projection on the fixed hemisphere is that of Dr. W. Bauersfeld, of the Zeiss Optical Company, Jena, who shortly after the close of the first World War stated this proposition:

"The great sphere shall be fixed; its inner white surface shall serve as the projection surface for many small projectors which shall be placed in the center of the sphere. The reciprocal positions and motions of the little projectors shall be interconnected by suitable driving gears in such a manner that the little images of the heavenly bodies, thrown upon the fixed hemisphere, shall represent the stars visible to the naked eye, in position and in motion, just as we are accustomed to see them in the natural clear sky."

Fully five years elapsed before the projection instrument emerged as a reality in August of 1924. The final result was surprising even to those who had designed the instrument. Of the comments made by astronomers, that of Dr. E. Stroemgren, of Copenhagen, is typical: "Never has a means of entertainment been provided which is so instructive as this, never one which is so fascinating, never one which has such general appeal. It is a school, a theater, a cinema in one; a schoolroom under the vault of heaven, a drama with the celestial bodies as actors."

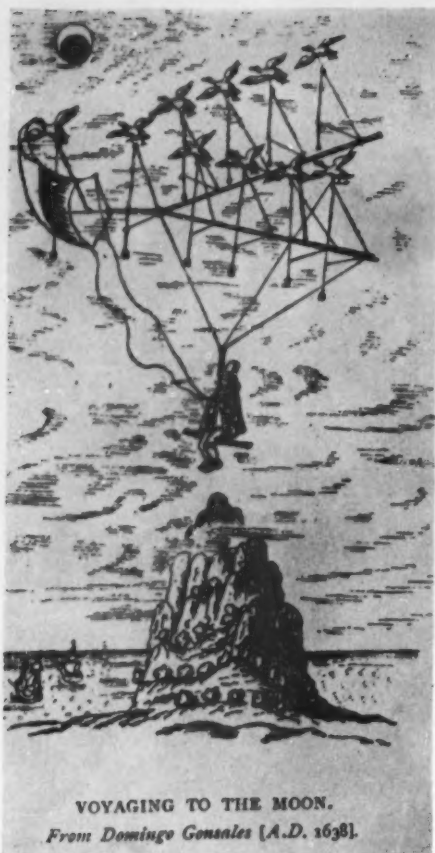
Many museums and other public institutions in America sent representatives to Europe to see the instrument and its performance, and plans were made by several cities to possess a plan-

etarium as soon as possible. Meanwhile, however, several installations were made in Germany before any were contracted for outside that country.

The first model of the instrument was capable of showing the skies only for one place; one was installed first on the roof of the Zeiss Works in Jena, then moved to the Deutsches Museum in Munich, while another was installed in Jena. But Dr. W. Villiger, of Zeiss, soon suggested a means of changing the design in such a way as to make it possible to show the sky for any place on the earth. This is the model of the instrument which has been made since 1926. Only two of the first model were built; one is in Munich; the other (which for a time replaced the original one on the factory roof in Jena) is in The Hague, Netherlands. The following list includes all the known installations; some of them are not now in continuous use.

Place	Date	Diameter of dome
Munich	July 5, 1925	33 feet
Barmen	May 18, 1926	67
Leipzig	May 20, 1926	80
Düsseldorf	May 23, 1926	98
Jena	July 18, 1926	77
Dresden	July 24, 1926	82
Berlin	Nov. 27, 1926	80
Vienna	Mar. 7, 1927	65
Nuremberg	Mar. 10, 1927	75
Mannheim	Mar. 22, 1927	82
Stuttgart	Apr. 16, 1928	82
Hanover	Apr. 29, 1928	65
Rome	Oct. 8, 1928	62
Moscow	Nov. 5, 1929	82
Hamburg	Apr. 15, 1930	67
Chicago	May 12, 1930	68
Stockholm	May 15, 1930	80
Milan	May 20, 1930	65
Philadelphia	Nov. 6, 1933	66
Los Angeles	May 15, 1935	75
New York	Oct. 3, 1935	75
Osaka	Mar. 13, 1937	..
Paris	....., 1937	..
Tokyo	Nov. 2, 1938	..
Pittsburgh	Oct. 24, 1939	65
The Hague	.....	..
Brussels	.....	..

(Continued on page 19)



# Facts Collected for a TRIP TO THE MOON

BY WILLIAM H. BARTON, JR.

*This month the Hayden Planetarium features its unsurpassed journey to the moon, during which an eclipse of the sun by the earth is observed from the vantage point of a lunar crater.*

ing guncotton, and gaskets were always made of India rubber. There were no radio, electrical instruments or controls; no flying suits or oxygen masks.

In planning a trip, the distance is always a consideration. The moon, when it is nearest the earth, is 221,463 miles away. That is the distance between the centers of the bodies. However, when the moon is in the observer's zenith, he is nearer than that by the radii of the earth and moon. The earth's radius is 3,963 miles at the equator and the moon's radius is 1,080 miles. The observer at sea level, then, may be as close as 216,420 miles to the moon's surface, under the most favorable circumstances. On the average the moon is 238,857 miles away, and when at apogee (greatest distance) it is at 252,710 miles. The moon's orbit around the earth is not a circle, but an ellipse with an eccentricity of 0.055, about as eccentric as the orbits of Jupiter, Saturn, or Uranus.

The moon's path about the earth does not coincide with the ecliptic, the apparent path of the sun about the sky. It is tilted 5.1 degrees. That is, we may see the moon as much as five degrees

higher than we see the sun, or five degrees lower than we ever see the sun. When the moon is full, it is just opposite the sun in our sky. In the latitude of New York, the sun's highest position is about noon June 22nd, when it is some 72° in altitude above the south point. If there were a full moon under the most favorable conditions on that date, the moon would cross the meridian at midnight at an altitude of only 21°.

On December 23rd, when the sun is lowest, about 26°, the moon may cross at 77°. That is, the moon is high on a winter night, and low on summer nights. This, coupled with the presence or absence of foliage, makes considerable difference in summer and winter moonlight. However, the conditions for these extreme values occur only at 19-year intervals.

Since the moon's diameter is about 1/4 the earth's, its surface is about 1/14 as great, and its volume only about 1/49 that of the earth.

Apparently, we do not have such a large surface to explore, but with our telescopes we can see only about half of it. It is well known that one side

IF ONE were planning to visit a foreign country, he should prepare for the trip by learning all he could about it before going. Then, having seen that country, his interest would stimulate him to do further reading upon his return. In the same way, only to a greater extent, a proposed trip to the moon would require preparation. The era of interplanetary travel has not come and it may never come. On the other hand, there are certain enthusiasts who are confident that it will, some day. There are many difficult problems to solve before it will but it would be rash to say "never." Never represents a long while and in the interim entirely new principles may be discovered, and undreamed-of inventions developed. But the problem of traveling to the moon is not going to be solved merely by developing present devices, making them larger, or faster, or stronger.

Forty years ago movie audiences were amused by seeing a group of foreign scientists, complete with top hats and umbrellas, enter a huge projectile and be shot to the moon. Their exploration of the lunar landscape and an encounter with the inhabitants, while not very good astronomy, were good entertainment.

Jules Verne wrote several fantasies about trips to the moon, and they, too, are most entertaining and somewhat instructive. The description of the trip sounds a little out of date. The travelers' car was lit by gas lights, the projectile was shot into space by explod-



The waning moon, 26 days old. Photo by R. G. Stephens.

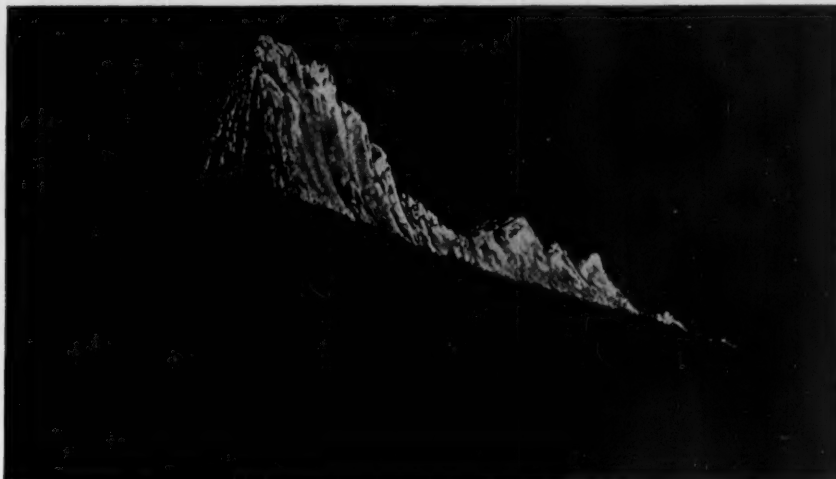
of the moon always faces the earth. (The moon's periods of rotation and revolution around the earth are equal.) The changing declination of the moon enables us to see a little beyond the north pole when the moon is somewhat south, and a little beyond the south pole when the moon is north. Then, too, the moon, while turning with uniform speed, does not move with uniform speed along its path. These irregularities produce librations that permit us to see a little "around the corner." The result is we see about 59 per cent of the whole area at one time or another. But 41 per cent is completely hidden to us — unless we do sometime actually make a trip to the moon.

The moon's mass is less than  $1/82$  that of the earth. This small mass of the moon means a relatively low gravity, since by the law of gravitation the force is proportional to the product of the masses involved. That is, any object, a stove or automobile, or your body, would have only  $1/82$  the force exerted upon it by the moon that it has here on the earth — if it were the same distance from the center. But on the moon's surface it is only about 1,000 miles, compared to about 4,000 on the earth, from the center. Gravitation varies inversely as the square of the distance. The distance factor, therefore, increases the comparative lunar gravity by about four times four, or more precisely, 13.3. Gravity (surface gravity, as we call it) is, therefore,  $13.3/82$  on the moon, about  $1/6$ . You would therefore weigh only  $1/6$  on the moon what you weigh on the earth. Our planetarium scales show visitors that they do weight only  $1/6$ . A 150-pound person stepping on the scales reads only 25 pounds.

For a long while people have been puzzled by the appearance of the moon on the horizon and overhead. It always looks larger when rising or setting. Of course it isn't. In fact it should look smaller, because it is farther away. If the moon actually went across your zenith it would be 4,000 miles nearer than when it was just rising or setting — and yet it looks smaller overhead.

Professor E. G. Boring and his staff of psychologists at Harvard have experimented and found the reason. The eye and its interpreter, the brain, see an object larger when it is directly in view than when the eyes have to be rolled up or down to see it. We used to believe that it had something to do with the surroundings, but apparently it is due to this peculiar physiological fact, which, in itself, still requires explanation.

The surface of the moon is of a most rugged character, and an exploring party would find it really rough going, much worse than we generally find on the earth. The relatively smooth areas,



The lunar Alps are steep and rugged. Drawing by L. Rudaux.

about half the visible surface, are called "seas" or *maria*. Upon close examination, even the floors of these maria are seen to be rough; clefts, small craters, hills, and other irregularities would make for bad travel. These areas are large — the Sea of Showers is 750 miles long.

Around these areas we sometimes find high mountain ranges, making of the whole a sort of gigantic crater. Heights of 20,000 feet and more are found among the lunar mountains. The next smaller feature is the ringed plain. Clavius is the largest of the lunar craters. It is nearly 150 miles in diameter and is bounded by a 20,000-foot mountain rim. The moon is so small, the curvature of its surface so great, that an observer standing in the center of this great plain would not be able to see the wall of mountains surrounding him. They would be below his horizon. An observer on the earth, a six-footer, can see 3.2 miles to the horizon, but on the moon he would see only half that far, 1.6 miles.

The craters are the most interesting feature of the moon's surface. They are seen by tens of thousands, ranging from those so small that they are just visible in the most powerful telescopes to large ones that merge into the ringed plains. There are no doubt many that we cannot see. Probably the most controversial problem connected with the moon is that of their origin.

There are, in general, two schools of thought, one holding to the volcanic origin, the other to the meteoritic. Some of the craters do resemble terrestrial

volcanoes, photographed from high altitudes. No ordinary lava flows appear to be visible on the moon. This rules out the volcanic origin for some students, but to others it merely means that the moon has only explosive craters. The large, flat surfaces of the maria and ringed plains appear very much like solidified surfaces. The mountains edging these plains might very well be the walls of gigantic craters. The low surface gravity of the moon would tend to permit much larger craters than we have on the earth. In some cases we find cones within cones, and on the earth there are similar formations. There appears to be no activity there now. The moon is a dead world. Its surface seems to be covered with dust, too, like an abandoned house. That dust is, perhaps, a part of the volcanic story, or many interpret it so, at least.

On the other hand, the advocates of the meteoritic theory have arguments on their side. There are meteor craters on the earth. Such craters can be produced by shooting bullets or dropping steel balls into mud. Drops of water falling on sand will make similar marks. A great many lunar craters have central peaks within the crater. These terrestrial experiments produce just such central peaks.

The rarity of meteoritic craters on the earth (in North America only seven are known) and their abundance on the moon may be accounted for by the presence of atmosphere here and its absence there. The atmosphere destroys a great many meteors that would, in its absence, fall intact upon the earth's surface.

The fact is that we do not really know what these lunar markings mean. There is the written story if anyone can read it. Look at the moon in a good telescope or at photographs of it and puzzle over the problem. It will take your mind off earthly things. Or better yet, take a trip to the moon and see for yourself.

#### EDITORIAL CORRECTION

In an error by the editors, in the first column on page 9 of the September issue, it was stated that Pyxis has neither Alpha nor Beta. This is not true, as reference to a star chart will verify. The Greek letters of Argus were divided only among Carina, Vela, and Puppis.

# VARIABLE STAR OBSERVERS MEET

By ELEANOR C. POLK, *Harvard College Observatory*

**F**OLLOWING time-honored custom, Harvard College Observatory was host to the American Association of Variable Star Observers at its 32nd annual meeting on October 8th and 9th. As expected, this gathering was not as large as in other years. In those days we could boast that people arrived from the four corners of the United States and Canada; this year we can say that they came from the four corners of New England and parts of New York. Often the "gang from Milwaukee" would drive day and night to get to Cambridge in time for the meeting; this year most members had difficulties coming much shorter distances.

The Maine Astronomical Society threatens the place long held by the Milwaukee group as the largest society "inside" the association. Let us hope that the saying of politicians quoted by our new president, Roy A. Seely, at the banquet, "As Maine goes, so goes the nation," proves to be true in astronomy as well. If so, the interest in astronomy should grow all over the country when we can all settle down again to the

peaceful pursuit of variable star observing.

Friday evening the Bond Club once again acted as host to the A.A.V.S.O. at a pleasant social and astronomical session, with the principal speaker Dr. B. W. Sitterly, now in Cambridge on leave of absence from Wesleyan's Van Vleck Observatory. Dr. Sitterly discussed the problem of measuring the distances of the stars and of the various methods used in determining those distances. By means of four different sets of comparisons one may attempt such measurements, Dr. Sitterly pointed out. The first of these, apparent versus real size, is not practicable; the second, apparent versus real brightness, is much used; the third, apparent versus real color, is very valuable; and the fourth, apparent versus real motion, is the one which includes "direct" trigonometrical parallaxes and to which Dr. Sitterly devoted most of his talk.

The regular business session of the association began at 10 o'clock Saturday morning with some 60 members and friends in attendance. Dr. Dirk

Brouwer, retiring president of the A.A.V.S.O., called the meeting to order.

Members stood for a moment of silence while the secretary, D. W. Rosebrugh, read the names of members who have passed on during the past year. Herbert Harris then talked of his friend, George R. Griffin, of Portland, Me., who was killed as the result of a motorcycle accident in California in September. Mr. Griffin had been a member of the A.A.V.S.O. for four years, and was one of our youngest and most active and accurate observers, until the time of his induction into the Army in 1942. We all remember him as a cheerful and friendly lad whose presence at meetings was maintained even if it meant driving most of the night after work to get there.

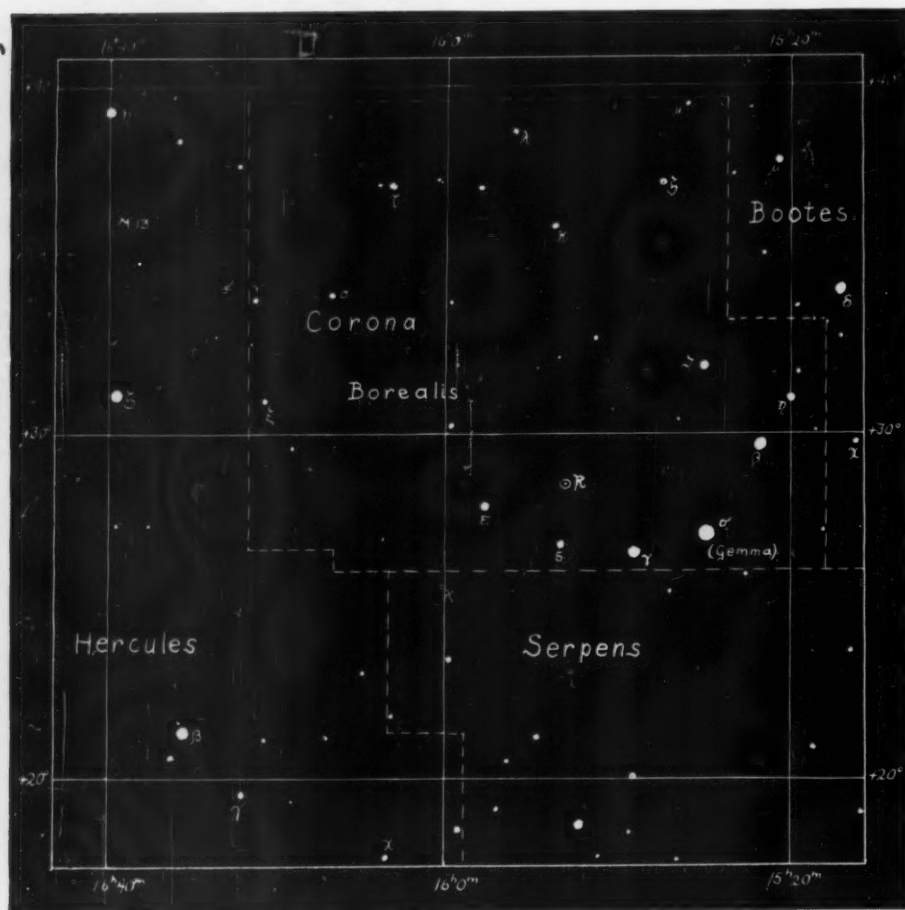
Leon Campbell then spoke of G. E. Ensor, of Pretoria, South Africa, who had been an active observer for 15 years and whose death was reported in *Sky and Telescope* last month. Mr. Ensor's faithful following of the southern variables helped materially in furthering our knowledge of those stars, and his contributions will be sorely missed.

The death in July of Dr. Frank Schlesinger ended the career of an outstanding American astronomer and a life member of the A.A.V.S.O. Dr. Brouwer, successor to Dr. Schlesinger as director of the Yale Observatory, brought us an appreciation of his life and contributions to astronomy.

Tribute to the late Prof. James R. Jewett, life member of the association and for many years friend and benefactor of the association and of Harvard College Observatory, was paid by Dr. Harlow Shapley. Prof. Jewett has made possible not only the furthering of research programs of the A.A.V.S.O. and the observatory, but also the publication of results of those researches.

Mr. Rosebrugh then announced that three members have been elected to life membership: Dr. Dorrit Hoffleit, now on leave of absence from Harvard; Mrs. Florence Gooch Woods, of Woodsville, N. H.; and Edward E. Friton, St. Louis, Mo. New annual members elected by the council are Mrs. Ada Arrowsmith, St. Albans, N. Y.; Miss Jessie L. Beach, Portland, Me.; J. Edgar Guimont, Montreal, Canada; Herbert J. Hopkins, Old Orchard Beach, Me.; James C. Robinson, Clovis, N. M.; Allen R. Sandage, Oxford, Ohio; Russell T. Wolfram, Mount Hamilton, Cal.; Laurence D. Yont, Concord, Mass.

Mr. Campbell told the story of Nova  
(Continued on page 20)



The light curves of the four R Coronae Borealis stars, each of which underwent decidedly rapid and extended diminution in light during the past year, were shown by the recorder. The position of their prototype is shown above.

IN THE first place, we must realize that the term *fireball* is an elastic one which may cover anything from a meteor as bright as Jupiter to bodies which are almost blinding in their brilliancy. Next, it must be understood that nobody can predict when a fireball will choose to appear except that, as a probability, on nights of so-called meteor showers when many meteors are visible, at least a few are likely to be quite bright. With these two warnings, we shall now proceed to describe how a fireball may be observed so that the description will be interpretable by others and hence have scientific value. The rules will be divided into two sections, the first applicable by persons who have some astronomical knowledge, including ability to recognize at least the brighter stars and constellations; the second, for persons without such advantages. As the vast majority even of educated and intelligent people fall unfortunately in the latter class, especial pains will be taken to give instructions which, while clear, are not too complicated to be followed by the casual observer.

We will begin, however, by an outline of what the astronomer needs, and therefore what the observer should strive to furnish.

As the fireball comes unannounced, there is always the element of surprise, and, with many people, consequent confusion—even in some cases, actual fright. The observer must report where he is so that *his position* can be located upon a standard map to within a mile, and he should give *the time* to the nearest minute. The *positions of the points in the sky* at which the object was first



A fireball records itself on a Harvard patrol-camera plate.

## HOW FIREBALLS SHOULD BE OBSERVED

BY CHARLES P. OLIVIER

*Director, Flower and Cook Observatories,  
University of Pennsylvania*

seen and last seen are most important. Then notes on *brightness, color, direction and duration of flight, explosions* and so on, are of great interest. Most of all, in the rare cases when a long-enduring train remains for a minute or longer, careful notes should be made of the *direction the train drifted and its changes of shape, and of how long it was visible*. As a fireball is rarely in sight more than a few seconds, one's best efforts are needed to make a full and accurate record. All notes should be made at once, before there is a chance to forget. If this is impossible, then the notes should be written down as soon as a place is reached where they can be made.

For those persons with some knowledge of astronomy, we have two general cases: (A) fireballs seen at night in a clear sky, (B) fireballs seen in daylight or at night with a cloudy sky. For (A) the obvious procedure is to determine the place among the stars where the object began and where it ended. This may be given by description with nearby stars as references or, better still, by later measuring off on a star map the right ascensions and declinations of these two points. For (B), not having reference points in the sky, one must fix

the path mentally with regard to houses, poles, trees, or any stationary object, and later the altitude and azimuth of the beginning and ending points may be determined from them. But if no such objects are available, due, say, to the fireball's path being high above the horizon, then "dead reckoning" or estimates of the co-ordinates must be made. Often the sun, and less often, the moon, is visible in daylight and will aid as a reference point in fixing the path. When a compass is used in determining directions, whether or not the correction to true north has been applied should always be clearly stated. Any form of protractor can be used in measuring the altitudes.

For those observers unfamiliar with stars and constellations, procedures (A) and (B) have to be pretty much the same. Only for (A) the moon is often available as a reference point, or there may be some planet so bright that even the roughest description of its position would permit its identification on reading a report. Similarly, a few of the brightest stars can be so identified if used. Lacking many or any of these aids, however, the observer is forced back upon the use of stationary objects, as described above, or to mere estimates



Fireballs sometimes appear to have large heads, as recorded in this 19th-century drawing.

for the position in the sky of the beginning and end points. In either case, if next day the observer can induce a person with a knowledge of angles and any means for measuring them to accompany him to the exact place of observation, good co-ordinates are often obtained by the second person measuring the points in the sky indicated by the first person, who actually saw the fireball. Without such human aid, however, an intelligent person can often use a compass for himself, or at any rate get approximate directions by using an auto map or a town plan. Some idea of the altitudes may be conveyed by comparing with that of the sun at a certain hour of the day, or of the moon that night at a given hour. Notes on general appearances, and so on, can be made almost as well by a person not trained in astronomy as by one who is. Everyone should avoid trying to use linear measure to describe angular heights or lengths, as, for instance, saying the object appeared 1,000 feet high and went 5,000 feet. Such attempts mean nothing to anyone but the narrator and are wholly useless.

*Bulletin No. 13* of the American Meteor Society is a questionnaire, with full instructions for answering the questions thereon, which was devised for use in reporting fireballs. This may be had on request by any person who wishes to report a fireball. Such a request should be addressed to the Flower Observatory, Upper Darby, Pa., which is the headquarters of the A.M.S.

A person who makes a full report may well ask what will be done with it. If only a single report on a given fireball comes, it is put in our file where it is available for statistical work, much of which has already been done and more of which will be done in the future. However, when good observations on the same object are made by two or more persons at some distance from one another, the height of the fireball's first appearance, the height of

## METEORITE

*Out of the awesome darkness  
Flashing across the sky,  
Darting past heavenly flowers  
Like a giant firefly,  
Shooting through miles in moments  
Over ethereal walls,  
Down to the earth in all splendor  
A silvery meteor falls:  
Out on a lonely desert  
Deep in a crater round,  
Firmly imbedded and warmly  
Covered with sandy ground,  
Weary of roaming at random,  
Longing for some cradling breast,  
Down to the earth in all splendor  
A meteor has come to rest.*

JOSEPH KNAPP

its ending point, the length of its path, its radiant point, and its approximate orbit in space can all be computed. As no observation is perfect, we get better results the more reports we have from different places. Indeed, it is not infrequent that 50 to 100 persons write us about a brilliant fireball. In such cases, unfortunately, most people do not know what is needed, never having read instructions such as those given above, so that the majority of such reports cannot be used in the numerical solutions. Nevertheless, the interest in meteors thus aroused often leads to some of these people becoming members of our society and thereafter taking an active part in the regular work. Also, when it seems that possession of *Bulletin No. 13* would elicit replies to important questions, probably left out of the original letter unintentionally, we often send this bulletin to the observer and so get a vastly more valuable record from him.

During many years before the war, the Hydrographic Office, U. S. Navy, to aid in this branch of scientific work, regularly published detailed observations of fireballs sent in by officers on ships. This valuable help had to be withdrawn when we entered the war, as the posi-

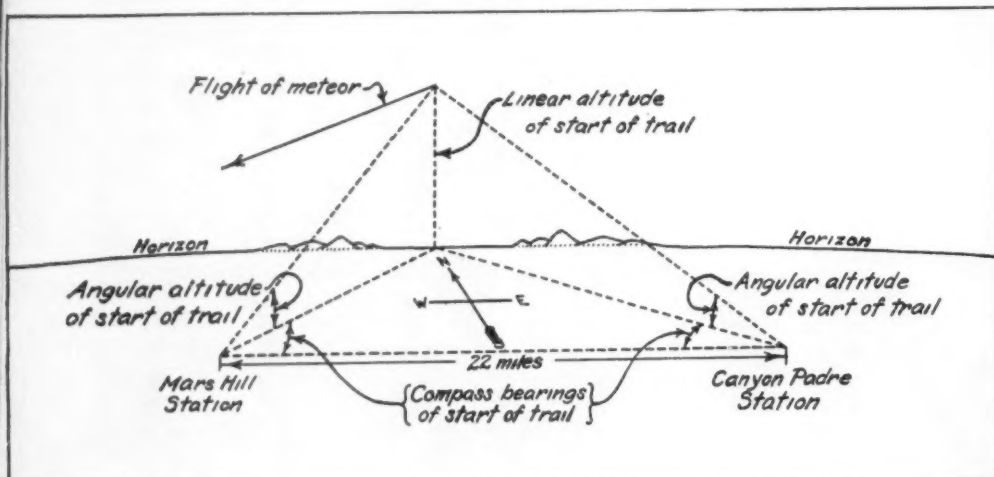
tions of ships was information the enemy could profit by, and the observations would be useless without the latitudes and longitudes of the ships being given for the times of observation. The Navy is particularly interested because meteoric phenomena furnish data for the study of the upper atmosphere, which in turn influences, in as yet many unknown ways, the surface air and that at the levels airplanes use. The drifts of meteor trains give by far the most available means for finding wind velocities at great heights, which is one reason their observation was so emphasized.

Very interesting correlations between the orbits of fireballs and comets are sometimes found. For instance, the writer has just solved two cases which indicate that both bodies belong to the Taurid stream, which was proved by F. L. Whipple, in 1940, to be connected with Encke's comet. It is also being more and more realized that meteors will be of great importance in any acceptable theory of the evolution of the solar system. In fact, they are very definitely one of the important keys to evolution in general, as meteorites, for instance, are the only bodies which are formed outside the earth and yet can be analyzed in our laboratories. And, so far as can be seen, there is no dividing line between meteors, fireballs, and meteorites, except one of mere size: meteorites survive their fiery trip through our atmosphere because they are large enough to do so—the others burn up before reaching the ground, their debris being fine dust and gas.

At A.M.S. headquarters, it is believed that we have the largest collection of records on meteors and fireballs ever made. This is being expanded constantly in every practicable way. We therefore earnestly request all persons interested in such matters to send us in the future, for permanent preservation, any observations they may make on fireballs, and also on meteor showers. We should, further, be glad to receive copies of old observations, which are often of very real value. And lastly, to persons who may wish to join the A.M.S., a most cordial invitation is given that they write for *Bulletin No. 15*, which describes methods and rules for membership.

## A.A.S. MEETING

The meeting of the American Astronomical Society, scheduled to be held in Cincinnati on November 5-7, 1943, on the occasion of the 100th anniversary of the founding of Cincinnati Observatory, will take place as originally planned, notwithstanding the unfortunate death of Dr. Elliott Smith, director of the observatory, on September 29th. Dr. Smith, who was 68 years old, had been director since 1940.



Using the well-known principles of triangulation, the height and location of the beginning point of a meteor are found from simultaneous observations.

# NEWS NOTES

## NOVA AQUILAE 1943

The effect of the war on astronomy is reflected in the story of the discovery and in the pre-discovery light curve of Nova Aquilae. A cablegram from K. Lundmark in Sweden was received at Harvard, asking for observations of both the Diamaca comet and the Hoffmeister nova. Astronomers had heard about the comet, but what *nova* and where? Further telegraphic procedure then brought the news on October 1st (via Professors Kopff of Berlin, Stroemgren in Copenhagen, and Lundmark of Lund) that on September 5th, C. Hoffmeister, director of the Sonneberg branch of the Berlin-Babelsberg Observatory, had discovered a 12th-magnitude nova in the constellation Aquila at  $19^h 45^m.5$ ,  $+8^\circ 6'$  (1855) very close to Altair. Searching earlier photographs of the region, he found that the star had attained a maximum brightness of about 7th magnitude between April 13th and May 2nd, nearly five months before.

When news of the discovery reached Harvard, Dr. S. Gaposchkin examined the available plates there. He reports maximum luminosity of 6.48 and 6.42 on April 28th and May 1st, respectively. His latest published observations, for the first part of September, showed the star oscillating between 10.7 and 11.45. Since April 28th, over 30 Harvard plates showing the nova had been obtained. In normal times, a nova as bright as magnitude 6.5 in the northern sky would probably not have failed to be detected. Visual and spectroscopic as well as photographic observations would have been secured.

Dr. A. N. Vyssotsky, of the Leander McCormick Observatory, reported to Harvard, as this issue went to press, that three plates taken with a prismatic camera on August 6th, August 24th, and September 1st, contained spectra of the nova. The first two spectra are essentially the same, and show emission bands from wave lengths 4100 to 5010; the third spectrum covers the region from 3800 to 4100. A faint, continuous spectrum appears on all three plates.

In view of events abroad, it is a bit surprising that it should have been a German astronomer who first discovered the nova. Evidently celestial photography is not being wholly neglected in that country either.

Nova Aquilae 1943 makes at least the tenth 20th-century nova discovered in the constellation Aquila. Nova Aquilae 1918 is the most famous, having attained a brightness of  $-1$ . Three others became of 7th magnitude or brighter—namely, the one in 1905 and two in 1936, also one at the close of the 19th century, in 1899. The rest had observed maxima ranging from 8.0

down to 11.2. Aquila thus appears a fairly happy hunting ground for nova game—not as good as Sagittarius, but neither so very cluttered with other stars.

## ASTRONOMICAL MEETINGS, ALWAYS

Astronomers, the war notwithstanding, seem to find time to get together at meetings and even to prepare speeches—the alibi for a meeting. The programs, of course, are not exactly what they used to be: with the proper precaution of alarm clocks or similar effective speech clippers, it is now possible for all papers to be presented—not some only by title.

As once previously, all astronomers in the far-reaching vicinity of Washington (to a radius of over 70 miles) were summoned together at short notice, at the Science Service Building on the evening of October 2nd, to hear astronomical news from visitor-in-town, Dr. Harlow Shapley, of Harvard. On October 8th, the A.A.V.S.O. met in Cambridge as usual for its annual meeting (see page 8). And this month, from the 5th to 7th, the American Astronomical Society, which just can't resist invitations, is holding its 71st meeting, thereby helping to commemorate the 100th anniversary of the founding of the Cincinnati Observatory. The account and report of papers of this meeting will appear in December.

## S. S. HENRY LOMB

A Liberty Ship launched at Baltimore on September 13th has been named in honor of Henry Lomb of the Bausch and Lomb Optical Company. The company, famous for its fine microscopes, spectroscopes, and other optical equipment (including astronomical), was founded in 1853 by the two men whose name it bears. So wide is the usage of Bausch and Lomb products that scientists of many fields will share a feeling of appreciation in the naming of this new Liberty Ship.

## SOLAR PROMINENCES

Within the past few years, the application of motion picture methods to observations with the interference polarizing monochromator has yielded a great many revealing facts about solar prominences. Since much of the work of this nature has been carried on at the Mount Wilson Solar Observatory, it is most fitting that a detailed outline of the classification of solar prominences should have been extended and perfected there. Thus, a current issue of the *Astrophysical Journal* contains a paper

by Dr. Edison Pettit, of Mount Wilson, on "The Properties of Solar Prominences as Related to Type."

The classification is based on extensive knowledge of physical facts (revealed largely by spectra) and descriptive material. Six principal classes of prominences (and numerous sub-divisions) are discussed: *quiescent*, *coronal*, *active*, *eruptive*, *sunspot* prominences, and *tornado* prominences. Some of these terms alone suggest the variety of "meteorological" conditions which must occur in the solar atmosphere. The various types are well illustrated both by drawings and photographs. Since some of the types naturally develop into others, it has been possible to arrange most of them within a logical metamorphic scheme.

## COMET DIAMACA

As announced on page 8 of last month's issue, on September 14th word reached this country by way of Zurich and Copenhagen that Diamaca at Bucharest, Rumania, had discovered an 8th-magnitude comet in the morning sky near Ursa Major, on September 10th. Several days later (September 18th), Leslie C. Peltier, of Delphos, Ohio, not having heard about Comet Diamaca, reported a new comet of 10th magnitude in the evening sky in Draco. Mr. L. E. Cunningham, comet wizard, immediately identified the two as the same comet. Between the two times of discovery it had moved nearly 60 degrees.

So faint a comet moving so rapidly offers difficulties in observing. Up to the time our news must go to press, only two approximate positions by Peltier (for September 18th and 19th), in addition to the one by Diamaca, have been received. These are not sufficient for an orbit determination. It is feared that the comet has won its elusive race, and vanished while astronomers were chasing the war instead.

## COL. PHILIP FOX RETIRES

Astronomer Philip Fox, formerly director of the Dearborn Observatory, and later of the Adler Planetarium, was among the first astronomers to lay aside, for the time being, studies of celestial affairs, in order to help bring the war to a faster finish. In a recent issue of the *Harvard Alumni Bulletin*, we note that Col. Fox, commanding the Harvard and Massachusetts Institute of Technology Electronics Training Schools, will begin terminal leave of absence on September 30th. This is in accordance with the revival of an Army rule prohibiting active duty for officers over 60 years of age. Although he retires from *active duty*, we predict the Colonel will continue as ever to set a good example in being active, in either or both the war and astronomical efforts.

# LUNAR CRATER

By J. FOSTER FOSTER, *Steward Observatory, University of Arizona*

The northern region of the moon contains a great variety of features. In the upper right is Crater Copernicus; to its left, Eratosthenes, adjoining the lunar Apennines. Plato is the large, dark crater along the lower side of Mare Imbrium, which occupies most of the picture. Mt. Wilson photograph.

pact would be circular only if the fall were vertical and would be decidedly elliptical in the majority of cases. But this argument ignores one basic fact. The crater is not produced by the meteor gouging a hole in the surface of the moon; it is caused by the explosion resulting from the sudden transformation of the energy of the meteor into heat. And such an explosion will produce a crater which is very nearly circular unless the angle of fall is exceptionally low. Meteor Crater in Arizona is an example of a crater with a nearly circular rim produced by a meteor striking at an angle of about 45 degrees.

The lack of random distribution of the lunar craters is an argument frequently used in support of the volcanic theory. Meteoritic craters should be found at random, while volcanic craters should tend to follow lines of weakness in the crust of the moon. Again one fact has been overlooked. A close inspection of the maria discloses traces of partially ruined craters on their surfaces or around their borders. This would seem to indicate that the maria were formed at a later date than were many of the craters and that the earlier craters in that area were destroyed. Then, however, distribution of the lunar craters is no longer significant; random distribution cannot be expected if craters over large areas have been destroyed.

The rays radiating from some of the lunar craters have never been adequately explained under any theory. Indeed, the various observers have not even agreed as to what they are. Some have thought that they are low mounds which were thrown out by the explosion which formed the crater from which they radiate. The velocity necessary to throw particles to the great distances observed has been calculated and found to exclude neither volcanic nor meteoritic origin. But the rays have never been observed to cast shadows, so perhaps they are not mounds at all. Other observers have come to the conclusion that the rays are cracks in the crust of the moon, but this does not seem likely, since they cross other lunar surface features, including mountains, without seeming to be even slightly deviated. Since the rays do cross these other features, the indication would seem to be that the craters from which they radiate are of comparatively recent formation. It has been shown that these ray craters have a random distribution, which suggests that they may be of meteoritic origin.

In many cases a central peak is to be found in a lunar crater, but in general

**T**HE ROUGH and pitted character of lunar topography has long been a matter of common knowledge. Even the smallest optical instruments disclose on the moon's surface features without any exact parallel on the earth, and in the largest reflectors the face of the moon is seen to be almost covered with over 30,000 crater-like depressions. These markings range from craterlets just visible in the largest telescope to huge ring plains 150 miles in diameter. Some of the craters have central mountain peaks; others have great systems of bright rays radiating from them, stretching for hundreds of miles across craters and mountains without any apparent deviation. Even bigger than the largest craters are the maria, or "seas." Once it was thought that these were bodies of water, but the telescope reveals that they are the smooth parts of the moon, the parts which contain only a few craters. In addition to the craters and maria, there are mountains, cliffs, and huge cracks in the surface.

The origin of these markings has been a subject of controversy among astronomers, and various theories have been advanced in explanation of their source. There are a number of facts which must be explained satisfactorily, and of the theories presented only two, the vol-

canic and the meteoritic, seem to have explained these facts sufficiently well to be seriously considered by most astronomers.

The great size of some of the craters has been one of the chief stumbling blocks for the advocates of both theories. It is especially difficult to explain why volcanic craters should be so much larger on the moon than on the earth. But in the distant past, when the earth's crust was very thin, it may be that volcanoes were much larger. Such ancient volcanoes on the earth would have long since been erased by erosion and weathering. On the moon, where there is little or no such action, they would have been preserved to the present. On the other hand, a crater of the diameter of the largest of those seen on the moon could be caused by a meteor comparable in size to a small asteroid. Although the proportion of such large craters is too great when the size of present-day meteors is considered, it is quite possible that there were many more of these large meteors when the solar system was young.

The nearly circular shape of the craters has been advanced as a strong argument on the side of the supporters of the volcanic theory. They argued that the crater caused by meteoritic im-

# THEORIES

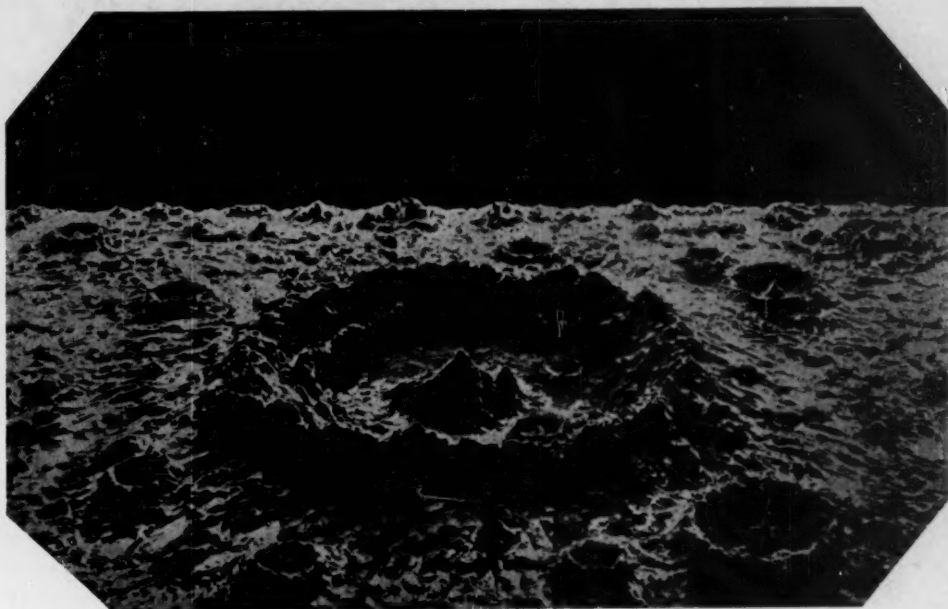
University of Arizona

there is no evidence of a crater at the top of the peak as would be expected if it were volcanic. However, it is quite possible that such a crater would be too small to be detected with existing telescopes. On the other hand, it is possible that these peaks could also be produced by the fall of meteors. Such peaks are sometimes found in the craters produced by bombs. Although none of the known meteor craters on the earth shows such central peaks, there is some indication that Meteor Crater originally possessed one which has since been obscured by erosion and deposition.

The rims of the lunar craters are, in general, complete and fairly regular, as are those of the meteor craters on the earth. The rims of volcanoes on the earth are frequently incomplete and usually irregular. The presence of small craters on the rims of the large ones is another difficulty with the volcanic theory. Although these occasionally appear on terrestrial volcano rims, they are much more common on the lunar craters.

In general, the floors of the lunar craters are below the level of the surrounding territory, while the floor of the typical terrestrial volcanic crater is well above the level of the surrounding country. In this, the lunar craters resemble known meteor craters and craters produced by explosives. There are a few craters, such as Kilauea on Mauna Loa in Hawaii, in which the floor is below the surrounding level, but these are comparatively rare. There are some exceptional lunar craters in which the crater floor is above the general level, and this evidence is brought forward by the exponents of the volcanic theory as proof of their arguments. But the phenomena associated with high-velocity impact can also explain craters of this type. A body moving at a high velocity will, upon impact, produce enough heat to vaporize itself and a part of the material surrounding the point of impact. But if the meteor is moving at a velocity very little higher than the minimum allowed by gravity, in the case of the moon about 1.5 miles per second, the heat would be sufficient to produce only partial vaporization, with liquefaction as an appreciable effect. The resulting explosion would be less violent, and the liquefaction would produce a higher and more level floor than is usual.

The maria could perhaps be explained as the result of the impact of large bodies such as asteroids, moving slowly enough so that the main result of the



The roughness of the moon's surface is shown in this Nasmyth and Carpenter drawing of a typical lunar crater.

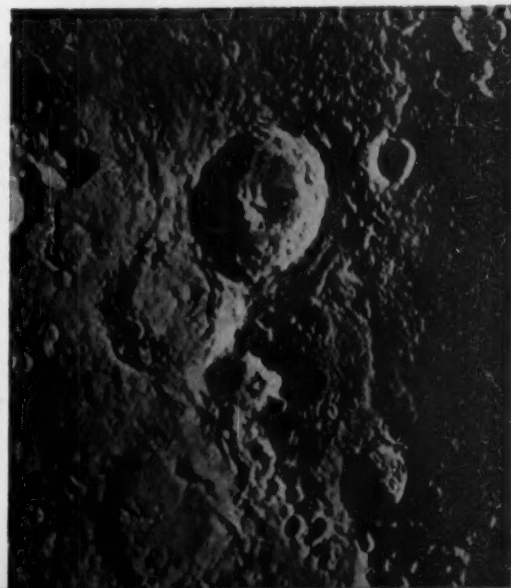
impact was one of liquefaction rather than vaporization. There is also another possible explanation of the maria which depends on a combination of meteoritic and volcanic action. If, at some stage in its history, the moon consisted of a liquid core covered by a thin solid crust, the shock of the impact of a meteor could have initiated activity closely resembling that of a true volcano. The meteor would produce the crater in the ordinary way, but the explosion would pierce the thin crust, letting the lava from the interior flow over the surrounding country. However, it seems more likely that the maria are simply lava flows of the ordinary kind.

Many people have tried in vain to find a newly formed lunar crater. But this lack of evidence of any new crater formation is also consistent with both the volcanic and the meteoritic theories. It is probable that volcanic activity, if it ever existed on the moon, would have ceased long ago; while if we assume the moon to be of the same age as the earth, calculation shows a meteor crater large enough to be seen from the earth would have been formed, on the average, once in 50,000 to 250,000 years. So it is not surprising that no new craters have been observed.

In conclusion, it seems probable that the maria and craters of the moon have been produced by a combination of both meteoritic and volcanic action. Perhaps the best picture begins with a gradually cooling, molten moon. As it became cooler, a thin crust, frequently broken by volcanic eruptions, formed over a large part of the surface. This was a relatively short period of wild volcanic activity during which the meteors that fell played an insignificant role.

Then, as cooling went on, the last of the liquid surface, the maria, became solid. Finally even the interior cooled and all volcanic activity ceased. All of this happened long ago, soon after the moon was born. But crater formation did not stop with the last of the volcanoes. Millions of meteors continued to fall on the moon, just as they do on the earth. Most of these meteors were too small to produce craters; their only effect was to pulverize the surface of the moon, and themselves, to a fine dust. Occasionally a larger meteor fell and blasted a new crater into the otherwise unchanging lunar surface. And it is thus that we see the moon today, a dead world, pitted by craters, subjected to a constant rain of tiny meteors. Sometime, perhaps tomorrow, perhaps not for hundreds or thousands of years, a new crater will be formed by one of the larger meteors which roam our solar system.

Some of the large craters overlap each other, while others contain smaller craters along their rims.



# Amateur Astronomers

## N.C.A.A.A. ELECTS NEW PRESIDENT

The 7th year of the National Capital Amateur Astronomers Association, Washington, D. C., began with 40 members in good standing. Election of officers took place on September 11th: president, Dr. Edgar W. Woolard; vice-president, Capt. U. S. Lyons; treasurer, George L. Skirm; secretary, Dorothy Harris.

Dr. Woolard is a meteorologist at the United States Weather Bureau, where he first served from 1919 to 1928. He was instructor in mathematics at George Washington University in 1928-29; assistant professor from 1929 to 1934, when he returned to the Weather Bureau. He is editor of the *Monthly Weather Review*, and has contributed articles to *Sky and Telescope*.

The new president and Mrs. Woolard were guests of the association at a get-acquainted dinner on October 2nd. Dr. Woolard spoke informally and presided at a short business meeting. The society is planning discussion groups in addition to its regular monthly meetings, which are held on the first Saturday of each month at the U. S. National Museum.

At the meeting on November 6th, H. A. Marmer, of the U. S. Coast and Geodetic Survey, will give an illustrated talk on tides. All persons in Washington and vicinity who are interested in astronomy are invited to attend and to apply for membership in the society, or they may communicate with the secretary, Miss Dorothy Harris, 1621 T St., N. W., Dupont 4200.

## DULUTH AMATEURS SUSPEND ACTIVITIES

Worthington S. Telford, secretary of the Duluth Astronomical Society, writes that his group has temporarily suspended its activities, because of a rather unfortunate sequence of events. Their president, E. C. Campbell, moved from the

city; John Darling, at whose private observatory the society met, died, and the observatory was closed for several months after his death. Mr. Telford offers, however, to meet and care for the interests of visiting amateurs.

The Duluth Observatory, now the property of State Teachers College, is now open under the direction of Dr. Harvelik, of the physics department of the college. The observatory is equipped with a 9-inch Brashear refractor and is open to the public usually during the first quarter of the moon. Mr. Telford is an attorney, with offices in the First National Bank Building of Duluth.

## NEW HAVEN SOCIETY RESUMES MEETINGS

At the September 11th meeting of the New Haven Amateur Astronomical Society, held at Yale University Observatory, J. J. Neale spoke on occultations of stars by the moon. This was a non-mathematical discussion of the more spectacular aspects of the subject, and was illustrated by crayon diagrams depicting the motions of the moon along the ecliptic, the regression of the moon's nodes, and other motions which affect the frequency and regularity of occultations. Various methods of clocking the events were also discussed.

On October 16th, Miss Mary Warren reported on a new theory of Cepheid variables suggested by Hoyle and Lyttleton in a recent number of the *Monthly Notices* of the Royal Astronomical Society. They suggest that if the known effects of close contact in a binary, such as Beta Lyrae, giving rise to a thin expanding shell or atmosphere, are carried to a logical conclusion, the phenomenon of Cepheid variation might well arise. Such a model explains the dependence of density, and perhaps of luminosity, on period, as well as being consistent with the observed relation between the radial velocity curve and the light curve. The model is tentative,

and was offered for criticism as such.

The speaker at the meeting on November 6th will be Miss Louise F. Jenkins, secretary of Yale University Observatory, and her topic: "Glimpses of Astronomy in the Orient." All amateurs in New Haven and vicinity are cordially invited to attend.

## NEW YORK NOTES

The Optical Division of the Amateur Astronomers Association in New York City is conducting its annual class in telescope making, in co-operation with the Hayden Planetarium, where the optical workshop is located. This is a combination lecture and laboratory course. Each student, under the guidance of an A.A.A. instructor, makes a 6-inch mirror, and also attends lectures in elementary optics and on the design and construction of telescope mountings.

The sessions begin November 9th, with enrollment continuing throughout November unless registration is completed to the limit of the class before the end of the month. Students attend one night each week, for 25 sessions. The fee of \$30.00 includes all materials. This course is accepted, along with other A.A.A. classes, for in-course credit by the Board of Education of New York City.

All persons interested in this or other classes conducted by the New York amateur group should communicate with the secretary, George V. Plachy, at the American Museum of Natural History.

"Solar Eclipses" is the title of the lecture before the A.A.A. on November 3rd, by Leo Mattersdorf, vice-president of the society. Mr. Mattersdorf has made a lifelong hobby of eclipse study and observation, in addition to his other activities as a member of the association. The second meeting of the month will be conducted by Miss Hazel Boyd; if weather permits, it will be devoted to outdoor observation and constellation study.

In an attractive 2-page spread, the recent Labor Day meeting of the A.A.A. jointly with the Bergen County Astronomical Society, at Teaneck, N. J., was reported and illustrated in *This Week* magazine (New York *Herald-Tribune*) for October 3rd.

## TENTH ANNIVERSARIES

The Rittenhouse Astronomical Society will join in the celebration of the 10th anniversary of the Fels Planetarium in Philadelphia. The November meeting will have as its theme the popularization of astronomy.

The Louisville Astronomical Society expects to celebrate its 10th anniversary this month with a meeting of special interest, including the showing of astronomical motion pictures.

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# BEGINNER'S PAGE

## SPECTRA — V: EXPLODING STARS

**B**RIGHT stars that have suddenly appeared in the sky where none had been observed before naturally attracted much attention from the earliest times. At first they were supposed to be new stars and so were called novae. With the advent of the telescope, it was discovered that a faint star had been previously observed at the spot where a nova appeared. Close watch also showed that after a period the nova gradually faded to about the brightness that had characterized its earlier life.

The natural surmise was that some sort of explosion had produced the phenomenon. But it was not until the spectroscope revealed the changes which took place during the comparatively brief space when it occupied the center of the stage, that any clear idea of the nature of the catastrophe was obtained.

Although our galaxy exhibits about 2,500 of these explosions per 100 years, only eight have been naked-eye attractions since the beginning of this century.

On June 5, 1918, an 11th-magnitude star in the constellation of Aquila in the Milky Way was apparently living the quiet life it had pursued for the previous 30 years. Two days later it suddenly increased 100-fold in brightness, and on June 9th, with a magnitude of  $-1$ , it outclassed all the stars except Sirius and Canopus. Its period of "stardom" was brief, for Nova Aquilae began to fade in a few days and in a fortnight it was down to the 3rd magnitude. Then, in a little over half a year it faded from view by the naked eye and is now back to approximately its original dimness. Even so, it is now about five times as luminous as our own sun.

Nova Cygni, in the last of August in 1920, jumped from the faintness of the 15th magnitude to the 2nd magnitude in just a few days, and then retired slowly to its former obscurity. Fortunately, some very fine spectra were obtained at the Lick Observatory which show some of the details of this event.

Following the reasoning of the previous articles, we learn that the stellar surface expands as increasing heat beneath it disturbs the equilibrium between the gravitational contraction of the star and the outward pressure of the heated gases and radiation within. As the expanding shell around the star increases in size, the entire object appears much brighter.

At first, the continuous spectrum from the stellar surface is crossed by the dark absorption lines of hydrogen and ionized calcium, iron, and titanium, which are present in the star's atmosphere. The Doppler effect shifts the lines toward the violet, which shows

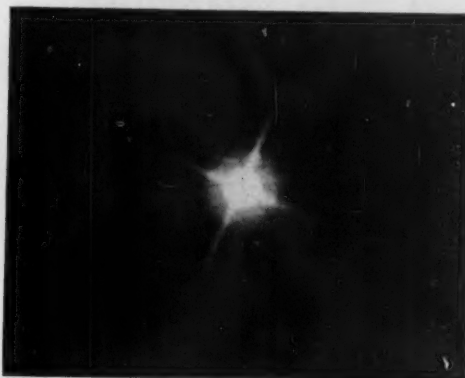
that the shell is rapidly approaching us in the line of sight. However, as the shell increases enormously in size, the outer portions are outside the lines of direct radiation from the star's surface and so emit bright spectral lines. The dark lines of hydrogen show several components which indicate the ejection of several shells expanding at different rates. The rate of expansion often exceeds 600 miles per second.

As the shells continue to expand, the pressure is so much less than any possible earthly vacuum and the temperature is so high that the metals lose many of their electrons and their radiation occurs in the far ultraviolet. Hydrogen, oxygen, and nitrogen still show their presence. A peculiar set of green "nebular" lines were a puzzle for some years, but as explained in a previous article, were traced to highly ionized oxygen.

The shells go off into space and eventually become large enough to be visible directly. In the case of Nova Persei, long before this occurred, a luminous cloud appeared around the star, but this cloud was being illuminated by the star, and the apparent expansion was a result of the outward motion of the burst of light at the time of maximum.

Stars like Nova Herculis (1934) and Nova Puppis (1942) bear a strong resemblance to their predecessors. The first of these is known as a "slow" nova, because its light fell off gradually after maximum. Nova Puppis, on the other hand, faded rapidly, and is one of the "fast" novae.

Below the surface of dense, hot, white stars, it is probable that there are regions where a small disturbance will upset the delicate equilibrium between gravitation and the radiation and gas pressures, and so produce the sudden explosion and expansion necessary to relieve the pressure, affecting, however,



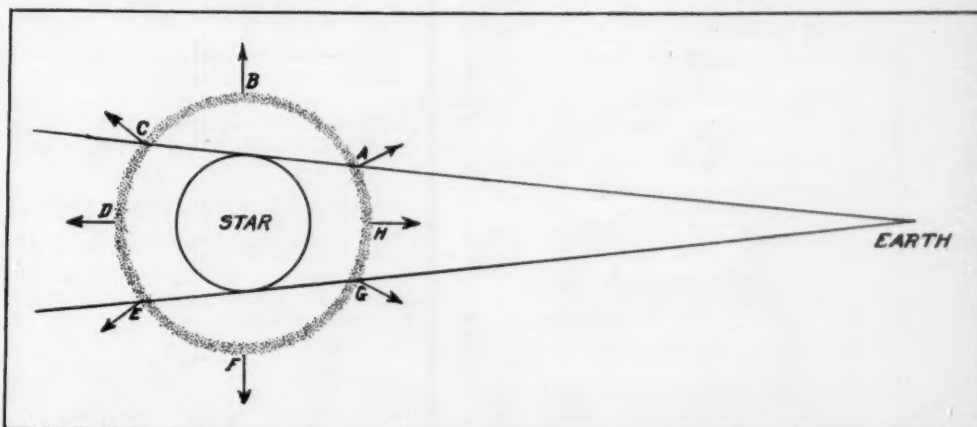
The expanding shell around Nova Aquilae (1918), as seen in 1927. The "rays" are caused by diffraction past the secondary-mirror support. Mount Wilson photo.

only the outer portions of the whole star.

Not to be outdone by the earth's maestros, nature also exhibits supernovae. Those in external galaxies are placed in two classes. Type I may reach a luminosity 100 million times that of the sun and fade rather rapidly. Type II may equal 10 million suns, fade slowly at first and then rapidly.

These far-distant catastrophes must be "super-colossal" to be visible at all. An extra large quantity of helium in the interior of a star, due to a long period of conversion of hydrogen to helium by the Bethe carbon cycle, would explain the prominence of helium and iron and the weakness of hydrogen in the spectra.

It is likely that Tycho Brahe's nova in 1572, which was visible in daylight, and Kepler's in 1604 were supernovae in our own galaxy. The Crab nebula, in Taurus, even now shows expanding portions and may be the result of a supernova in 1054, a star which was recorded by both Chinese and Japanese astronomers as being as bright as Jupiter.



Some portions (as at H) of the expanding shell of gas around a nova contribute absorption lines to its spectrum, while others (as at B and F) produce emission lines in which the Doppler effect is comparatively small.

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## BOOKS AND THE SKY

### AIRCRAFT NAVIGATION

H. Stewart, A. Nichols, S. A. Walling and J. C. Hill. The Macmillan Company, New York, 1943. 146 pages. \$2.00.

AS IF in answer to a suggestion made here in reviewing the Kingsland-Seager book in September, this nearly full-sized aerial navigation text was published on August 10th. It contains at least twice the material of the earlier volume, written by four English authors instead of two, and covering many additional subjects. It is still short of what one might consider the ideal text of its kind—perhaps we shall have to wait until after the war for time to co-ordinate into one treatise all the new methods and shortcuts which are being developed at present.

There are two parts to this newest book on air navigation. The first is devoted to theory, the second to practice. We question the theoretical classification of subjects like star identification and map reading. The book jacket states there are 450 problems, and the answers are provided for those who wish to check their own work.

In the chapter on star identification, this book is not unlike any other navigation text we have seen, in that it starts the navigator off learning stars instead of constellations. How any permanent acquaintance with night skies can be ob-

tained from 1½ pages of introduction and 5½ pages of description and charts, we do not understand. In a perfectly clear sky, near home, one may be able to apply the instructions here given, that it "is necessary to know only about twenty-five of the important stars" and that this is "really a simple matter if an observer can recognize two or three of the conspicuous constellations (or groups of stars), and use certain of their leading stars to form guides or pointers to other stars." But what one does in a partly cloudy sky, in unfamiliar latitudes, is not clear.

Of course, this is the reason such devices as Rude's Star Finder have been developed, but in aerial navigation, where time is of the essence, the navigator who can recognize constellations at a glance, and consequently the stars they contain, has a great advantage. Few navigation instructors seem to recognize this fact, to which most amateur astronomers will readily attest. It is to be hoped that some day a navigation text will include a better and more practical treatment of this important subject.

Two of these authors previously collaborated in producing a companion volume, **Aircraft Mathematics**, which has been used by "more than 100,000 men with the RAF, the Canadian Air Force and with men going into the United States Army and Navy Air Services." It is probable that this newest publication will equal this mark. C. A. F.

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# ASTRONOMICAL ANECDOTES

## DAYTIME COMETS, A PORTRAIT LENS, AND THREE TONS OF STAR MAP

IN SEPTEMBER of 1941, this department carried something about the earliest photographs of comets—those of Donati's comet of 1858, at Harvard and on Walton Common in England. There, too, there was mention of the photograph of the "Tewfik" comet of May 17, 1882, during the total eclipse of the sun observed at Sohag in Egypt. This comet was only one of three which were seen in the daytime, in that same year!

On March 17, 1882, C. S. Wells at the Dudley Observatory in Albany discovered a comet which became bright enough on June 5th to be seen on the meridian at about noon. Indeed, this comet was so involved with daylight and twilight that it failed to attract wide public attention.

Andrew A. Common (who made two 60-inch mirrors now in the possession of the Harvard College Observatory) was impressed by the discovery of the Tewfik comet so close to the sun, and he began to examine the neighborhood of the sun almost daily, hoping to catch another. On September 17th, according to Agnes Clerke's *History of Astronomy During the 19th Century*, "he saw a great comet close to, and rapidly approaching the Sun. It was, in fact, then within a few hours of perihelion. Some measures of position were promptly undertaken; but a cloud-veil covered the interesting spectacle before midday was long past. Mr. Finlay at the Cape was more completely fortunate. Divided from his fellow-observer by half the world, he unconsciously finished, under a clearer sky, his interrupted observation. The comet, of which the silvery radiance contrasted strikingly with the reddish-yellow glare of the Sun's margin it drew near to, was followed 'continuously right into the boiling of the limb.' . . . It vanished as if annihilated. So sudden was the disappearance that it was at first thought that the comet must have passed *behind* the Sun. But . . . the observers (Finlay and Dr. Elkin) at the Cape had witnessed a genuine transit. . . . The bulk of the comet was of too filmy a texture, and its presumably solid nucleus too small, to intercept any noticeable part of the solar rays."

These were not the first observations of the "Great September Comet" of 1882, which passed within 300,000 miles of the photosphere. It was seen at Auckland, New Zealand, as early as September 3rd, and on the 11th, Cruls, of Rio de Janeiro, reported it. Finlay first saw it on the 8th.

On September 18th, the comet rose

before the sun. It was very brilliant, and on this day and the next it was seen with the unaided eye during daylight, all over the world; one needed only to shield his eyes from direct sunlight. It remained visible to the unaided eye in the night sky until March 7, 1883.

But before it had faded, a new era in astronomy had begun. Sir David Gill, Her Majesty's Astronomer at the Cape of Good Hope, invited Mr. Allis, a local photographer, to strap his camera to the side of the large equatorial telescope of the observatory, and to photograph the comet. Now it must be remembered that earlier photographs of comets had been made; on June 24th of the preceding year, Common at Ealing and Draper in America had photographed Tebbutt's comet, and photographs of a sort had been made as early as 1858.

But the camera used by Allis was a Dallmeyer portrait camera, with a lens of  $2\frac{1}{2}$  inches aperture and 11 inches focal length. Exposures varied from half an hour to an hour, and the images of many hundreds of stars were shown. Immediately it became evident that the slow, inaccurate visual methods of making star catalogues were things of the past. In one hour, a small camera and a photographic plate could do without sensible error what one man, with a large telescope, could hardly do in a year.

The Brothers Henry in Paris made the first photographic telescope, with an aperture of 13 inches and focal length of 134 inches, and demonstrated the feasibility of a photographic map of the sky. And in 1887, at the instigation of Admiral Mouchez, director of the

Paris Observatory, and Sir David Gill, who had seen the possibilities revealed in the comet photograph of 1882, the "Astrographic Conference" met in Paris, and planned the "Great Star Map" (the *Carte du Ciel*). Eighteen observatories were to be equipped with telescopes like those made by the Brothers Henry, and each observatory was to take about 2,500 plates, half with exposures of almost an hour, the other half of shorter exposure. The 22,154 plates bearing the long exposures were calculated to weigh about three tons.

The project is not yet finished. So much overlapping work, superseding the purposes of the original venture, will make it unnecessary to complete the plan in its original form. But from this project there has come much useful information, and much guidance for other projects. R.K.M.

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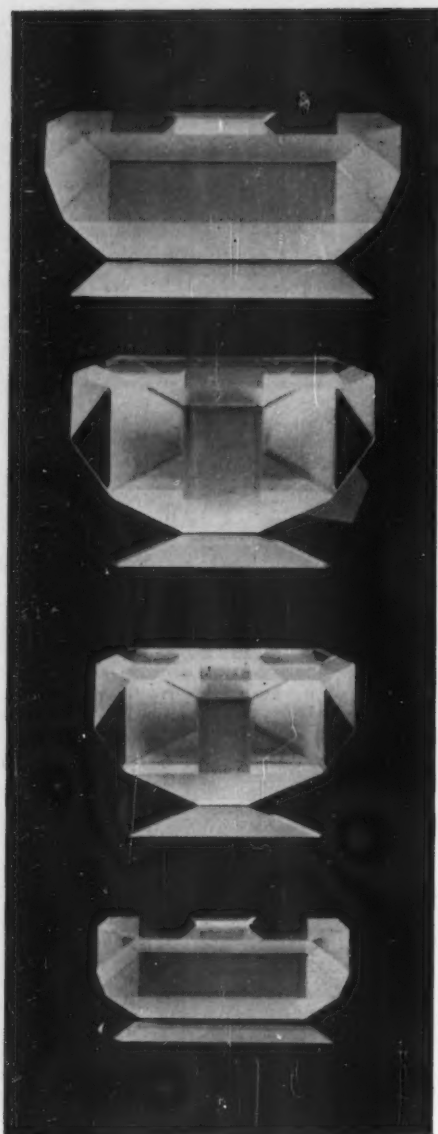
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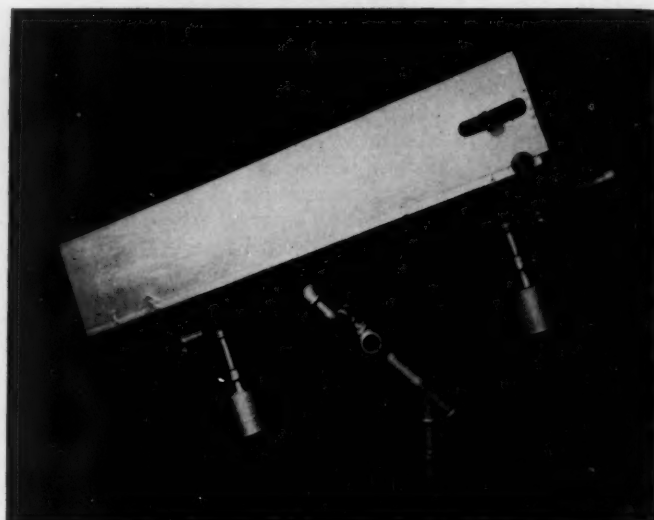
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## GLEANINGS FOR A. T. M.s

FROM THE MAIL BAG

This mounting for a Newtonian reflector is designed by Max H. Mattes to overcome the frequently inconvenient position of the eyepiece.



### Rotating Telescope Mount:

Mr. Max H. Mattes, of New York, submits his development of a type of mounting which overcomes the frequently uncomfortable location of the eyepiece on a reflecting telescope in certain positions.

In order to maintain the eyepiece of a Newtonian telescope in a comfortable position, it is sometimes the practice of telescope makers to provide so-called "slip rings" on the tube. These are expensive and difficult to make, and the arrangement shown will take care of the difficulty quite as satisfactorily.

Instead of the telescope tube being mounted directly to the declination axis, a long shaft is provided, which runs the entire length of the tube. The tube is attached to this shaft by means of two supports, properly counterbalanced, which permit the tube to be rotated on the shaft into a comfortable position without chang-

ing the direction of the line of sight.

The accompanying photograph shows the arrangement. It could, of course, be made more elaborate, with shafting and bronze or roller bearings, but the pipe arrangement shown works very satisfactorily. A small sliding counterweight is located at the bottom of the shaft to provide adjustment for different weights of eyepiece.

MAX H. MATTES  
Brooklyn, N. Y.

### Metal Mirrors:

Mr. G. H. Lutz, who has been developing metals for telescope mirrors for many years, sends us the following summary:

The first telescope mirrors to be made were of metal, "speculum," an alloy of copper and tin being the usual material. Herschel and Lord Rosse made many mirrors of this type, some as large as six feet in diameter. It was only subsequent to their time that the process of silvering was discovered, and metal mirrors fell into discard for many reasons. Speculum metal was hard and difficult to work; it tarnished easily, and when tarnished had to be completely repolished, and temperature effects upon a solid metal mirror were considerable. The silver-on-glass surface was easy to wash off and reapply when tarnished—the glass was easier to work and less sensitive to temperature.

Many years ago, I became interested in the problem of metal mirrors for telescopes and began to work upon it. Building machinery at that time, I was in close touch with the metal industry and able to work upon new alloys. A suitable alloy, stellite, was eventually developed—one which is unaffected by temperature or atmospheric conditions—non-tarnishable and stronger than steel.

One of the principal advantages of metal mirrors, especially for the larger telescopes, is the great amount of time saving possible in the construction. No months or year of annealing are necessary—48 hours after it is poured, it is ready for grinding, polishing, and figuring.



G. H. Lutz and his 36¼-inch metal mirror, f/3.3, tipped over for testing. Note the reflection of palm trees and wires outside of the garage.

It has been only chance that has prevented a large metal-mirror telescope being constructed in this country. The writer was working upon a 41-inch metal mirror for the U. S. Naval Observatory when it was decided that it should be made of glass. The 1929 financial disaster put a stop to plans to mount a 25-foot metal-mirror telescope in southern Florida. A metal mirror was seriously considered for the 200-inch telescope for Mt. Palomar. The late Robert Henkel, of Detroit, who was the instigator of the southern Florida proposition, wished to alter more ambitious plans to a 36-inch metal-mirror telescope, and work upon this was begun, but was uncompleted at the time of Mr. Henkel's death. His friend, Thomas Edison, considered carrying the project to completion, but he, too, passed away before anything substantial was accomplished.

It is the writer's ambition to build one large metal mirror and see it mounted in a telescope. If he can do this, the information he has gathered relative to melting and mixing, casting, machining and grinding metal telescope mirrors, as well as polishing them to the final optical surface, will be made available to everyone.

G. H. LUTZ  
Reseda, Cal.

## THE PLANETARIUM

(Continued from page 5)

All the instruments of the improved model are alike, except for certain small details which have no effect upon the final performance of the instrument. The price of the instrument has varied with the rate of exchange; it is stated as 315,000 RM, which amounted in normal times to approximately \$75,000. When one considers that this initial cost must be more than doubled, in order to provide a suitable building and the equipment for ventilating the planetarium chamber, it seems less surprising that there are so few of them in existence. On the other hand, our own country would seem well able to possess a dozen or so more, to serve our large centers of population. Several other cities have entertained the idea with more or less seriousness, and it is likely that before many more years have passed there will be others, of the present design or (since the German patents will soon expire) perhaps of American manufacture.

Many of the foreign installations were paid for from public funds and are

associated with school systems and other public works. In the United States, the generosity of public-spirited citizens has been the source of most of the necessary money.

In Chicago, the Adler Planetarium and Astronomical Museum is the gift of Max Adler, former official of Sears, Roebuck and Company. The building houses an unparalleled collection of antique astronomical and mathematical instruments, as well as the projection planetarium.

In Philadelphia, the Fels Planetarium was given to The Franklin Institute by Samuel S. Fels, soap manufacturer and philanthropist. In addition to the projection planetarium, the astronomical exhibits of The Franklin Institute include an observatory where visitors may look through a 10-inch refractor and a 24-inch reflector, the latter instrument the largest in the world devoted exclusively to public instruction. In the corridor in the Fels Planetarium, an image of the sun is sometimes projected by a vertical telescope of 10 inches aperture, fed by a coelostat on the roof of the building.

In Los Angeles, the Griffith Observatory was the bequest of Col. Griffith J. Griffith. While the projection planetarium is the principal exhibit, there are many others, including a 12-inch refractor for public observation, and a solar telescope. Allied sciences are included in the exhibits of the museum.

In New York, the projection planetarium and the great orrery or Copernican planetarium in the room below were the gift of Charles Hayden. The building was constructed as a self-liquidating project of the Reconstruction Finance Corporation. It contains a magnificent collection of meteorites, as well as the other astronomical exhibits of the American Museum of Natural History, with which the Hayden Planetarium is associated.

In Pittsburgh, the Buhl Planetarium and Institute of Popular Science was provided for from funds allotted by the Buhl Foundation, established by Henry Buhl, Jr., Pittsburgh merchant and philanthropist. The building contains astronomical and allied exhibits, and an observatory containing a 10-inch horizontal telescope fed by a siderostat.

Substitutes for the instrument as installed in these five institutions have been devised, but none is capable of the performance which is built into the Zeiss planetarium. One domestic instrument is in the Springfield, Mass., Museum of Natural History; it projects many stars, but not the planets. Another instrument, designed specifically to project only the stars necessary to navigation instruction, has been constructed by the Bausch and Lomb Optical Company for the United States Navy.

(Continued next month)

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## VARIABLE STAR OBSERVERS MEET

(Continued from page 8)

Puppis that filled us all with pride. The A.A.V.S.O. has bestowed the David B. Pickering Nova Medal for the first time on one of its own members, Dr. Bernhard H. Dawson, of La Plata, Argentina, for his discovery of Nova Puppis on November 8, 1942. The gold medal was recently presented to Dr. Dawson by a representative of the United States Embassy at the dedication of a new telescope at the observatory in Buenos Aires. Other trained A.A.V.S.O. eyes picked up Nova Puppis, but not before Dr. Dawson had telegraphed the news of his observation.

The recorder's 12th annual report shows that even though fewer observations are being made the light curves are still, for the most part, well maintained. Few maxima of important stars have been missed; more than 1,000 observations of Nova Puppis were made from November through June of this year. The grand total of observations for the year is 31,205. C. F. Fernald, of Wilton, Me., again leads the list with 4,536; then come R. P. deKock, of South Africa, with 3,054, and F. Hartmann, of St. Albans, N. Y., with 2,353. Mrs. W. Kearons, of Fall River, Mass., our "first lady," made the commendable total of 1,528. Good track of southern variables is due almost exclusively to our two remaining South African observers, deKock and Cousins. The monthly "Variable Star Notes" continue to appear in *Popular Astronomy*, and the usual publications of *Bulletins*, *Variable Comments*, and *Harvard Annals* continue. The occultations committee is active, but the work of the other committees has been curtailed by the war.

Lewis Boss, Miss Hoffleit, Dr. William Holt, and Marjorie Williams were elected to the council. Mr. Seely, of New York City, was elected president, to succeed Dr. Brouwer.

First business of the afternoon session was the bestowing of the Merit Award, the highest honor the association confers; it has been given seven times in the past nine years for exceptional contributions and allegiance to the association. Those who received the first six are: L. C. Peltier, ace observer and comet finder; W. T. Olcott, founder and lifelong secretary; the Reverend T. C. H. Bouton, for over 30 years a regular observer; David B. Pickering, charter member, donor of the Nova Medal; E. H. Jones, top observer for years; and D. F. Brocchi, chart maker and faithful observer. This year another outstanding member is added to this illustrious group: Charles W. Elmer.

For more than 20 years, whenever there has been a job to be done in the

association, Mr. Elmer has filled it efficiently and with excellent good humor. His interest in astronomy and the A.A.V.S.O. led him to membership on the Visiting Committee of Harvard College Observatory and to partnership in the Perkin-Elmer Corporation, makers of precision optical equipment serving astronomy and industry.

In responding to the award, Mr. Elmer characteristically pointed out that he did not feel this signified his demise in the association. Certainly not, Mr. Elmer, there will always be a job for you, official or otherwise.

The session for papers began with a dual approach by Secretary Rosebrugh and President Seely to the problem of observing that classic of eclipsing stars, Algol, which has aroused the interest of amateur astronomers by apparently running off schedule. Mr. Campbell discussed novae of the past year. Nova Cygni, found at Mount Palomar, has a light curve similar to that of Nova Herculis of 1934. He also pointed to a real and mysterious systematic difference between estimations of magnitude of Nova Puppis by northern and southern observers. The former made the star on the average one magnitude too bright. Nova Aquilae, latest discovery, is described on page 11, this issue.

Dr. Brouwer talked about the problem of measuring stellar parallaxes on photographic plates. Difficulties arise from differences in magnitude (corrected by rotating sectors); from the hour-

angle effect (requiring taking exposures near the meridian); from apparent differential shifting of the plate emulsion (overcome by a second exposure oriented 180 degrees to the first); and from other unexplained small errors.

A pleasant afternoon tea was had at the observatory residence, and in the evening, 51 persons gathered at the Harvard Faculty Club for dinner. Dr. Dean B. McLaughlin, secretary of the American Astronomical Society, reviewed that society's 45-year history. Mr. Harris showed some beautiful Kodachrome slides of last year's meeting, and of the equipment of various Maine amateurs. Dr. Bart J. Bok gave us an insight into the trials and tribulations of spreading astronomical knowledge internationally.

And lastly, we heard that traditional review, by Dr. Shapley, of the "high and low lights of astronomy" during the past year. The low is indisputably the mystery of the Diamaca comet which was observed in Europe, independently found by our own Peltier, but which disappeared before we could find out much about it. On Harvard plates of where it ought to be, the elusive object is hidden "under the emulsion." The high light of the year, Dr. Shapley believes, will be completely revealed only when the war is over; we shall look back upon 1943 as the year when astronomical "gadgetry" made strides that eventually revolutionized methods of research.

## THE MOON AND PLANETS IN THE EVENING AND MORNING SKIES



In mid-northern latitudes, the sky appears as at the right at 6:30 a.m. on the 7th of the month, and at 5:30 a.m. on the 23rd. At the left is the sky for 6:30 p.m. on the 7th and for 5:30 p.m. on the 23rd. The moon's position is marked for each five days by symbols which show roughly its phase. Each planet has a special symbol, and is located for the middle of the month, unless otherwise marked. The sun is not shown, although at times it may be above the indicated horizon. Only the brightest stars are included, and the more conspicuous constellations.

**Mercury** is too close to the sun for observation.

**Venus**, a morning star, will be in conjunction with and 22' south of Neptune on November 13th. It will be at greatest elongation west, 46° 40', on the 16th.

**Mars**. See special article on page 22.

**Jupiter** is in Leo, best observed in the late morning sky.

**Saturn** and **Uranus** are in Taurus.

**Neptune** is in Virgo.



## DEEP-SKY WONDERS

**THIS** month finds the following objects in good position for observation with moderate-sized telescopes. Descriptions are from Norton's *Star Atlas*.

**Andromeda.** M31, 0h 40m.0, +41° 0'; the Great Nebula is visible to the naked eye as a hazy spot; in small telescopes it appears long and oval, brightening toward the center, with an almost star-like nucleus. Long exposures with large telescopes are required to resolve the

outer parts into stars. N.G.C. 7662, 23h 23.4, +42° 12'; a remarkable bright, slightly elliptical planetary, 32" x 28", almost starlike with low power—annular in a 10-inch telescope.

**Aquarius.** M2, 21h 30m.9, -1° 4'; a globular cluster about 7' in diameter, fine for large telescopes. N.G.C. 7009, 21h 1m.4, -11° 34'; the Saturn nebula, a very bright, bluish, planetary nebula, 25" x 17", its thin "rays" visible only in large telescopes.

## STARS FOR NOVEMBER

as seen from latitudes 30° to 50° north, at 10 p.m. and 9 p.m. on the 7th and 23rd of the month, respectively. The 40° north horizon is a solid circle; the others are circles, too, but dashed in part. When facing north, hold "North" at the bottom, and similarly for other directions. This is a stereographic projection, in which the flattened appearance of the sky itself is closely reproduced, without distortion.

# OBSERVER'S PAGE

All times mentioned on the Observer's Page are Eastern war time.

## MARS RETURNS TO THE EVENING SKY

ON NOVEMBER 28th, Mars will be 50,172,000 miles from the earth or about 482,000 miles closer than its distance on December 5th, when it will be in opposition to the sun. Throughout this article any linear distances will be based on an astronomical unit of 93,000,000 statute miles and the positions of the planet will be apparent and not heliocentric.

The distance at this opposition will not be particularly close; in fact, it will be almost midway between the nearest and farthest possible separations. The minimum distance of slightly less than 35,000,000 miles occurs when Mars reaches perihelion in August, whereas the maximum separation at opposition, 63,000,000 miles, happens when Mars reaches its aphelion in late February or early March.

Situated in Taurus, halfway between Alpha and Beta Tauri (Aldebaran and Nath), Mars will cross the meridian very high in the sky just before or after 1:00 a.m. war time (depending on one's longitude). Its magnitude,  $-1.7$ , will be very similar to that of Sirius and of Jupiter at this epoch. Sirius, magnitude  $-1.6$ , and 41 degrees south of Mars, will be two hours east of the meridian, while Jupiter, magnitude  $-1.8$ , will appear in the east  $1\frac{1}{2}$  hours above the horizon. The star and the two planets will form an enormous triangle bisected by the Milky Way and including some of the finest winter constellations.

Regulus will shine  $2^\circ$  east of Jupiter, and other 1st- or 2nd-magnitude stars lying within or close to the triangle will be Procyon, Capella, Castor, Pollux, Betelgeuse, Bellatrix, Nath, Aldebaran. Also, there will be the best parts of the constellations, Gemini, Canis Major, Auriga, and Orion, plus the clusters, Hyades, Pleiades, and Praesepe. The planet Saturn,  $-0.2$ , will also be within the triangle,  $12\frac{1}{2}$  degrees east of Mars and close to its own opposition to the

sun. We shall, however, discuss Saturn more fully next month. The motions of both Mars and Saturn will be retrograde.

During the week between November 28th and December 5th, the disk of Mars will appear in its full phase, with an apparent diameter of  $17''.5$ . A telescopic magnification of 100x will cause the planet to appear to be of the same size as our moon appears to the unaided eye. The inclination of Mars' polar axis will permit us to see a few degrees beyond the south pole, and since Mars at that time will be well past perihelion, the south polar cap should be plainly visible. The position angle of the axis of rotation,  $328^\circ$ , places the polar cap  $32^\circ$  east of the true south point of the disk.

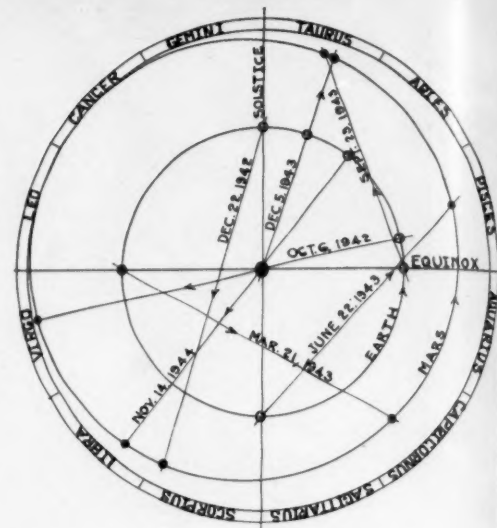
Once in every year, each of the major planets, Jupiter, Saturn, Uranus, and Neptune, disappears in the glare of the sun for a month or six weeks while transferring from the evening to the morning sky. This is the result of their relatively slow orbital motions when compared to the earth's speed in its orbit. The angular distances of  $30^\circ$ ,  $12^\circ$ ,  $4^\circ$ , and  $2^\circ$ , traveled respectively by each of the four planets above, may be compared to the  $360^\circ$  traversed by the earth in the same period of one year.

The orbital speed of Mars, however, 15 miles per second, is only slightly slower than that of the earth, 18 miles per second, but although the distance traveled by the former along its orbit in one revolution around the sun is more than  $1\frac{1}{2}$  times the earth's, Mars completes about  $190^\circ$  of its course while the earth makes one complete revolution. But Mars and the earth are moving in the same direction, so that as we see the planet, it appears to move about  $260^\circ$  a year, and its disappearances near the sun are separated by nearly two years.

On October 6, 1942, Mars was in direct line or in conjunction with the sun as seen from the earth. This condition will prevail again on November 14, 1944. During this time of two years, one month and one week, the earth will have traveled twice around the sun, plus an added  $29^\circ$ , while Mars will have completed but one circuit, plus the same  $29^\circ$ . On the diagram, I have shown the planets' positions on those dates, as well as their relative positions for the subsequent winter and summer solstices, spring and fall equinoxes, and for the opposition on December 5, 1943.

At the conjunction of October 6, 1942, Mars and the sun appeared to be in the constellation of Virgo, and the planet was 244,730,000 miles from the earth. On November 14, 1944, Mars and the sun will be in Libra, the planet 235,410,000 miles from the earth. The two prior conjunctions occurred on July 24, 1938, and August 30, 1940, in Cancer and Leo, respectively, at 246,730,000 and 248,780,000 miles. The latter figure is within 50,000 miles of the maximum possible separation of the two planets; that would occur at

BY JESSE A. FITZPATRICK

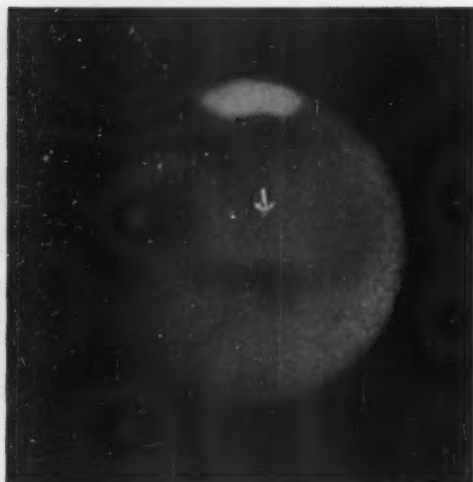


a conjunction on August 26th, when the earth passes Mars' perihelion.

As the reader may know, the variation of these nearest and greatest distances is found in the eccentricity of the orbits of the two planets, particularly that of Mars. If we consider these orbits to be circular, the center of Mars' path is 13,235,000 miles from the sun's center in the direction of Leo, and that of the earth is 1,553,000 miles toward Sagittarius.

If we follow the motions of the two planets in the direction indicated by the arrows on their orbits and subsequent to the October 6, 1942, conjunction, we shall first note that on December 22, 1942, Mars as seen from the earth is apparently in Scorpio and slightly west of the sun. This is too close for observation, particularly so for observers in mid-northern latitudes; and even if it could be seen, Mars would appear as an inconspicuous 2nd-magnitude star. By March 21, 1943, the planet is higher in the sky, appearing in Capricornus. The angular distance from the sun has increased and the separation from the earth has decreased noticeably. The magnitude,  $+1.2$ , makes it as brilliant as Pollux, Spica, or Antares, but it still is hardly an object for observation, as evidenced by the fact that no data is given in the *American Ephemeris and Nautical Almanac* for its "Physical Observation" between July 2, 1942, and April 1, 1943.

By the time the earth has reached the summer solstice, on June 22, 1943, conditions for observation have improved. Mars is now in Pisces, placing it north of the celestial equator, and its magnitude,  $+0.7$ , is a trifle brighter than that of Altair. At the autumnal equinox, September 23rd, the ruddy planet is in Taurus and  $21^\circ$  north of the sun; it has a magnitude of  $-0.4$  and rises before 10:30 p.m. in the latitude of our local station. Its distance of 75,000,000 miles from the earth brings it within the range of small telescopes so the growth in size of the polar cap may be observed through the following months. From this last date, the eastward motion slows perceptibly and the planet moves only  $8^\circ$  farther along in its orbit until October 28th, when the

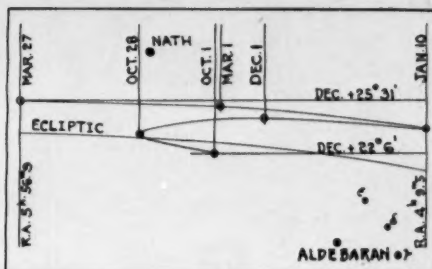


Mars and its south polar cap. The arrow indicates a region where seasonal changes are to be observed. Lowell Observatory photo.

western or retrograde movement begins.

Following opposition on December 5th, the earth, with its faster orbital speed, will be in advance of Mars instead of behind; the planet will reach the western sky before midnight. This latter condition will prevail earlier each evening, until Mars disappears in the glare of the sun; the cycle will end with the conjunction on November 14, 1944.

I feel that a peculiar paradox concerning the diagram on the facing page should be explained. At the beginning of this article it was noted that the positions of Mars were apparent and not heliocentric, and if, for example, we examine the relative positions of the earth and Mars at the summer solstice, June 22, 1943, the earth is, as shown, at R.A. 18<sup>h</sup>, or 270° heliocentric longitude, and the apparent position of Mars is, as shown, R.A. 1<sup>h</sup> 12<sup>m</sup>, or 18° east of the vernal equinox and in Pisces. Mars at this time is actually at heliocentric longitude 335°, about where the letter A is in the word MARS on the diagram. The explanation of the discrepancy lies in the very great distance of the stars as com-



pared with the relative nearness of the planet. A line from the earth through Mars' true heliocentric position would, if extended far enough, terminate in Pisces, 18° east of the equinox, and it is there that we see the planet. However, if the ring of stars that we call the zodiac could be contracted so the stars had the same distance from the sun as Mars, we would see the planet in Aquarius.

### THE LEONIDS

The Leonid meteor shower may be expected to reach its maximum on the 15th and 16th of this month.

### OCCULTATIONS—NOVEMBER, 1943

Local station, lat. 40° 48'.6, long. 4<sup>h</sup> 55<sup>m</sup>.8 west.

Date	Mag.	Name	Immersion	P.*	Emersion	P.*
Nov. 4	5.9	19 Capricorni	9:27.8 p.m.	53°	10:32.8 p.m.	268°
6	6.7	BD —11° 5912	7:29.9 p.m.	79°		
6	6.2	70 Aquarii	9:38.2 p.m.	4°	10:19.6 p.m.	303°
8	6.8	BD —2° 69	6:00.1 p.m.	35°		
13	5.7	63 Tauri	5:18.9 a.m.	52°	6:21.2 a.m.	290°
14	5.2	64 Orionis	11:52.8 p.m.	98°	1:05.6 a.m. (15)	240°
15	5.7	68 Orionis	5:39.1 a.m.	132°	6:40.8 a.m.	231°
17	6.1	209 B Geminorum	1:46.1 a.m.	93°	3:09.9 a.m.	270°
30	6.7	BD —21° 5444	7:28.7 p.m.	72°		

\*P is the position angle of the point of contact on the moon's disk measured eastward from the north point.

### JUPITER'S SATELLITES

On November 7th and 21st, the four moons will be west of the primary, and on the 27th they will be on the east side. On the 7th, and prior to 2:38 a.m. on the 27th, they will be in numerical order, with I nearest to Jupiter.

Jupiter's four bright moons have the positions shown below at 5:15 a.m., E.W.T. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. From the American Ephemeris.

	West		East
1	1	3	4
2	1	3	4
3	1	3	4
4	1	3	4
5	1	3	4
6	1	3	4
7	1	3	4
8	1	3	4
9	1	3	4
10	1	3	4
11	1	3	4
12	1	3	4
13	1	3	4
14	1	3	4
15	1	3	4
16	1	3	4
17	1	3	4
18	1	3	4
19	1	3	4
20	1	3	4
21	1	3	4
22	1	3	4
23	1	3	4
24	1	3	4
25	1	3	4
26	1	3	4
27	1	3	4
28	1	3	4
29	1	3	4
30	1	3	4

### PHASES OF THE MOON

First quarter .. November 4, 11:22 p.m.  
Full moon .... November 11, 9:26 p.m.  
Last quarter .. November 19, 6:43 p.m.  
New moon .... November 27, 11:23 a.m.

### MINIMA OF ALGOL

November 3, 8:14 p.m.; 18, 4:19 a.m.;  
21, 1:08 a.m.; 23, 9:57 p.m.; 26, 6:46 p.m.

## PLANETARIUM NOTES

*Sky and Telescope* is official bulletin of the Hayden Planetarium in New York City and of the Buhl Planetarium in Pittsburgh, Pa.

### ★ THE BUHL PLANETARIUM presents in November, A JOURNEY TO MARS.

Once more the puzzling planet Mars is making a near approach to the earth, and shines again in our night sky so brightly as to direct our thoughts to its many mysteries. Astronomers still are attempting to read the real story of this fiery red planet's faintly revealed surface markings.

In this sky show, visitors first see Mars set against its background of autumn stars, and as it actually appears through powerful telescopes. But then we see Mars as it might appear if we could travel far beyond the troublesome atmosphere of the earth, to view the planet near at hand. What sort of life might there be on Mars today? What might have inhabited Mars millions of years ago? What of the "Martians" and the "canals"—of the green patches that mottle the planet? These are the questions presented visually and graphically in "A Journey to Mars."

### ★ THE HAYDEN PLANETARIUM presents in November, TRIP TO THE MOON. (See page 6.)

In December, THE WISE MEN'S STAR. One program that never loses its appeal, because of its timeliness and timelessness, is the Christmas Story. What was the Wise Men's star? Was it a meteor? a comet? a nova? Various opinions will be discussed, with music and special projection devices bringing to everyone the atmosphere of Christmas.

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### ★ SCHEDULE HAYDEN PLANETARIUM

Mondays through Fridays.....2, 3:30, and 8:30 p.m.  
Saturdays .....11 a.m., 2, 3, 4, 5, and 8:30 p.m.  
Sundays and Holidays.....2, 3, 4, 5, and 8:30 p.m.

★ STAFF—Honorary Curator, Clyde Fisher; Curator, William H. Barton, Jr.; Associate Curator, Marian Lockwood; Assistant Curator, Robert R. Coles (on leave in Army Air Corps); Scientific Assistant, Fred Raiser; Lecturers, Charles O. Roth, Jr., Shirley I. Gale, John Saunders.